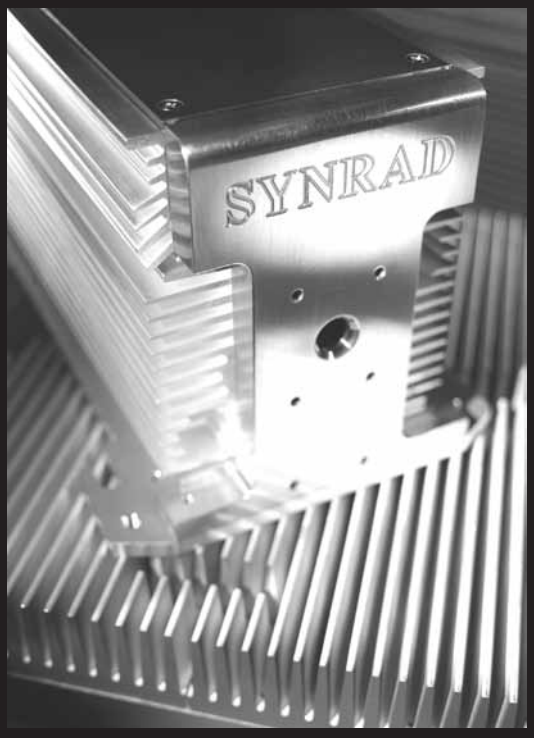
firestar t series



operator's manual

SYNRAD®

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firestar t series

Firestar® t60/t80/t100
D version
Operator's Manual

Version 1.7

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Warranty information

This is to certify that Firestar® t-Series lasers are guaranteed by SYNRAD, Inc. to be free of all defects in materials and workmanship for a period of one year from the date of purchase. This warranty does not apply to any defect caused by negligence, misuse (including environmental factors), accident, alteration, or improper maintenance. We request that you examine each shipment within 10 days of receipt and inform SYNRAD, Inc. of any shortage or damage. If no discrepancies are reported, SYNRAD shall assume the shipment was delivered complete and defect-free.

If, within one year from the date of purchase, any part of the Firestar t-Series laser should fail to operate, contact the SYNRAD Customer Service department at 1.800.SYNRAD1 (outside the U.S. call 1.425.349.3500) and report the problem. When calling for support, please be prepared to provide the date of purchase, model number and serial number of the unit, and a brief description of the problem. When returning a unit for service, a Return Authorization (RA) number is required; this number must be clearly marked on the outside of the shipping container in order for the unit to be properly processed. If replacement parts are sent to you, then you are required to send the failed parts back to SYNRAD for evaluation unless otherwise instructed.

If your Firestar t-Series laser fails within the first 45 days after purchase, SYNRAD, Inc. will pay all shipping charges to and from SYNRAD when shipped as specified by SYNRAD Customer Service. After the first 45 days, SYNRAD will continue to pay for the costs of shipping the repaired unit or replacement parts back to the customer from SYNRAD. The customer, however, will be responsible for shipping charges incurred when sending the failed unit or parts back to SYNRAD or a SYNRAD Authorized Distributor. In order to maintain your product warranty and to ensure the safe and efficient operation of your Firestar t-Series laser, only authorized SYNRAD replacement parts can be used. This warranty is void if any parts other than those provided by SYNRAD, Inc. are used.

SYNRAD, Inc. and SYNRAD Authorized Distributors have the sole authority to make warranty statements regarding SYNRAD products. SYNRAD, Inc. and its Authorized Distributors neither assumes nor authorizes any representative or other person to assume for us any other warranties in connection with the sale, service, or shipment of our products. SYNRAD, Inc. reserves the right to make changes and improvements in the design of our products at any time without incurring any obligation to make equivalent changes in products previously manufactured or shipped. Buyer agrees to hold SYNRAD harmless from any and all damages, costs, and expenses relating to any claim arising from the design, manufacture, or use of the product, or arising from a claim that such product furnished Buyer by SYNRAD, or the use thereof, infringes upon any Patent, foreign or domestic.

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Sales and Applications

SYNRAD's Regional Sales Managers work with customers to identify and develop the best CO_2 laser solution for a given application. Because they are familiar with you and your laser application, use them as a first point of contact when questions arise. Regional Sales Managers also serve as the liaison between you and our Applications Lab in processing material samples per your specifications. To speak to the Regional Sales Manager in your area, call SYNRAD at 1.800.SYNRAD1.

Customer Service

For assistance with order or delivery status, service status, or to obtain a Return Authorization (RA) number, contact SYNRAD at 1.800.SYNRAD1 and ask to speak to a Customer Service representative.

Technical Support

SYNRAD's Regional Sales Managers are able to answer many technical questions regarding the installation, use, troubleshooting, and maintenance of our products. In some cases, they may transfer your call to a Laser, Marking Head, or Software Support Specialist. You may also e-mail questions to the Technical Support Group by sending your message to support@synrad.com or to support@winmark.com.

Reference materials

Your Regional Sales Manager can provide reference materials including Outline & Mounting drawings, Operator's Manuals, Technical Bulletins, and Application Newsletters. Most of these materials are also available directly from SYNRAD's web site at http://www.synrad.com.

European headquarters

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laser safety

Hazard information

Hazard information includes terms, symbols, and instructions used in this manual or on the equipment to alert both operating and service personnel to the recommended precautions in the care, use, and handling of Class IV laser equipment.

Terms

Certain terms are used throughout this manual or on the equipment labels. Please familiarize yourself with their definitions and significance.

⚠ Danger: Imminent hazards which, if not avoided, will result in death or serious injury.

⚠ Warning: Potential hazards which, if not avoided, could result in death or serious injury.

⚠ Caution: Potential hazards or unsafe practices which, if not avoided, may result in minor or moderate injury.

Caution: Potential hazards or unsafe practices which, if not avoided, may result in product damage.

Important Note: Important information or recommendations concerning the subject under discussion.

Note: Points of particular interest for more efficient or convenient equipment operation; additional information or explanation concerning the subject under discussion.

General hazards

Following are descriptions of general hazards and unsafe practices that could result in death, severe injury, or product damage. Specific warnings and cautions not appearing in this section are found throughout the manual.

⚠ Danger
serious personal injury

This Class IV laser product emits ***invisible*** infrared laser radiation in the 10.6 µm CO_2 wavelength band.

Do not allow laser radiation to enter the eye by viewing direct or reflected laser energy. CO_2 laser radiation can be reflected from metallic objects even though the surface is darkened. Direct or diffuse laser radiation can inflict severe corneal injuries leading to permanent eye damage or blindness. All personnel must wear eye protection suitable for 10.6 µm CO_2 radiation when in the same area as an exposed laser beam. Eyewear protects against scattered energy but is not intended to protect against direct viewing of the beam—never look directly into the laser output aperture or view scattered laser reflections from metallic surfaces.

Enclose the beam path whenever possible. Exposure to direct or diffuse CO_2 laser radiation can seriously burn human or animal tissue, which may cause permanent damage.

laser safety

Hazard information

⚠ Danger
serious
personal
injury

This product is not intended for use in explosive, or potentially explosive, atmospheres.

⚠ Warning
serious
personal
injury

U.S. customers should refer to and follow the laser safety precautions described in the American National Standards Institute (ANSI) Z136.1-2007 document, *Safe Use of Lasers*. Procedures listed in this Standard include the appointment of a Laser Safety Officer (LSO), operation of the product in an area of limited access by trained personnel, servicing of equipment only by trained and authorized personnel, and posting of signs warning of the potential hazards.

European customers should appoint a Laser Safety Officer (LSO) who should refer to and follow the laser safety precautions described in EN 60825-1, 2007—*Safety of Laser Products*.

⚠ Warning
serious
personal
injury

Materials processing with a laser can generate air contaminants such as vapors, fumes, and/or particles that may be noxious, toxic, or even fatal. Material Safety Data Sheets (MSDS) for materials being processed should be thoroughly evaluated and the adequacy of provisions for fume extraction, filtering, and venting should be carefully considered. Review the following references for further information on exposure criteria:

ANSI Z136.1-2007, *Safe Use of Lasers*, section 7.3.

U.S. Government's *Code of Federal Regulations*: 29 CFR 1910, Subpart Z.

Threshold Limit Values (TLV's) published by the American Conference of Governmental Industrial Hygienists (ACGIH).

It may be necessary to consult with local governmental agencies regarding restrictions on the venting of processing vapors.

⚠ Warning
serious
personal
injury

The use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

laser safety

Hazard information

Firestar® t-Series lasers should be installed and operated in manufacturing or laboratory facilities by trained personnel only. Due to the considerable risks and hazards associated with the installation and operational use of any equipment incorporating a laser, the operator must follow product warning labels and instructions to the user regarding laser safety.

To prevent exposure to direct or scattered laser radiation, follow all safety precautions specified throughout this manual and exercise safe operating practices per ANSI Z136.1-2007 at all times when actively lasing.

Always wear safety glasses or protective goggles with side shields to reduce the risk of damage to the eyes when operating the laser.

A CO_2 laser is an intense heat source and will ignite most materials under the proper conditions. Never operate the laser in the presence of flammable or explosive materials, gases, liquids, or vapors.

The use of controls or adjustments or performance of procedures other than those specified herein may result in exposure to hazardous ***invisible*** laser radiation, damage to, or malfunction of the laser. Severe burns will result from exposure to the laser beam.

Safe operation of the laser requires the use of an external beam block to safely block the beam from traveling beyond the desired work area. Do not place your body or any combustible object in the path of the laser beam. Use a water-cooled beam dump or power meter, or similar non-scattering, noncombustible material as the beam block. Never use organic material or metals as the beam blocker; organic materials, in general, are apt to combust or melt and metals act as specular reflectors which may create a serious hazard outside the immediate work area.

Other hazards

The following hazards are typical for this product family when incorporated for intended use: (A) risk of injury when lifting or moving the unit; (B) risk of exposure to hazardous laser energy through unauthorized removal of access panels, doors, or protective barriers; (C) risk of exposure to hazardous laser energy and injury due to failure of personnel to use proper eye protection and/or failure to adhere to applicable laser safety procedures; (D) risk of exposure to hazardous or lethal voltages through unauthorized removal of covers, doors, or access panels; (E) generation of hazardous air contaminants that may be noxious, toxic, or even fatal.

Disposal

This product contains components that are considered hazardous industrial waste. If a situation occurs where the laser is rendered non-functional and cannot be repaired, it may be returned to SYNRAD, Inc. who, for a fee, will ensure adequate disassembly, recycling, and/or disposal of the product.

Additional laser safety information

The SYNRAD web site (http://www.synrad.com/LaserFacts/lasersafety.html) contains an online laser safety handbook that provides information on (1) Laser Safety Standards for OEM's/System Integrators, (2) Laser Safety Standards for End Users, (3) References and Sources, and (4) Assistance with Requirements.

In addition, the Occupational Safety and Health Administration (OSHA) provides an online Technical Manual (located at http://www.osha.gov/dts/osta/otm/otm_iii/otm_iii_6.html). Section III, Chapter 6 and Appendix III are good resources for laser safety information.

Another excellent laser safety resource is the Laser Institute of America (LIA). Their comprehensive web site is located at http://www.laserinstitute.org.

laser safety

t-Series label locations

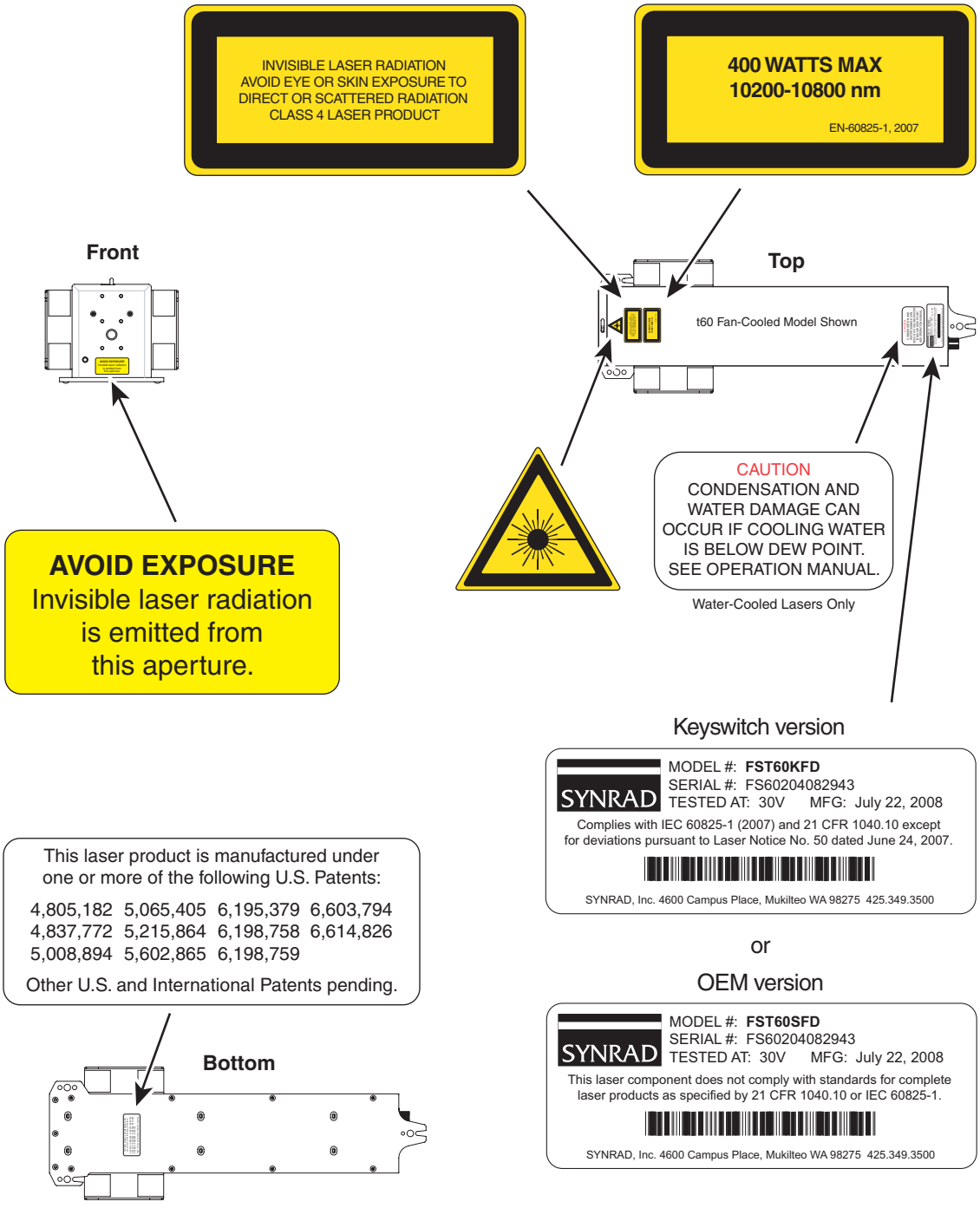

INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO
DIRECT OR SCATTERED RADIATION
CLASS 4 LASER PRODUCT
400 WATTS MAX
10200-10800 nm
EN-60825-1, 2007
Front
Top
t60 Fan-Cooled Model Shown
AVOID EXPOSURE
Invisible laser radiation
is emitted from
this aperture.
CAUTION
CONDENSATION AND
WATER DAMAGE CAN
OCCUR IF COOLING WATER
IS BELOW DEW POINT.
SEE OPERATION MANUAL.
Water-Cooled Lasers Only
Keyswitch version
SYNRAD
MODEL #: FST60KFD
SERIAL #: FS60204082943
TESTED AT: 30V MFG: July 22, 2008
Complies with IEC 60825-1 (2007) and 21 CFR 1040.10 except
for deviations pursuant to Laser Notice No. 50 dated June 24, 2007.
SYNRAD, Inc. 4600 Campus Place, Mukilteo WA 98275 425.349.3500
or
OEM version
SYNRAD
MODEL #: FST60SFD
SERIAL #: FS60204082943
TESTED AT: 30V MFG: July 22, 2008
This laser component does not comply with standards for complete
laser products as specified by 21 CFR 1040.10 or IEC 60825-1.
SYNRAD, Inc. 4600 Campus Place, Mukilteo WA 98275 425.349.3500
This laser product is manufactured under
one or more of the following U.S. Patents:
4,805,182 5,065,405 6,195,379 6,603,794
4,837,772 5,215,864 6,198,758 6,614,826
5,008,894 5,602,865 6,198,759
Other U.S. and International Patents pending.
Bottom

Figure 1 Firestar t60/t80/t100 hazard label locations

laser safety

RF power supply label locations

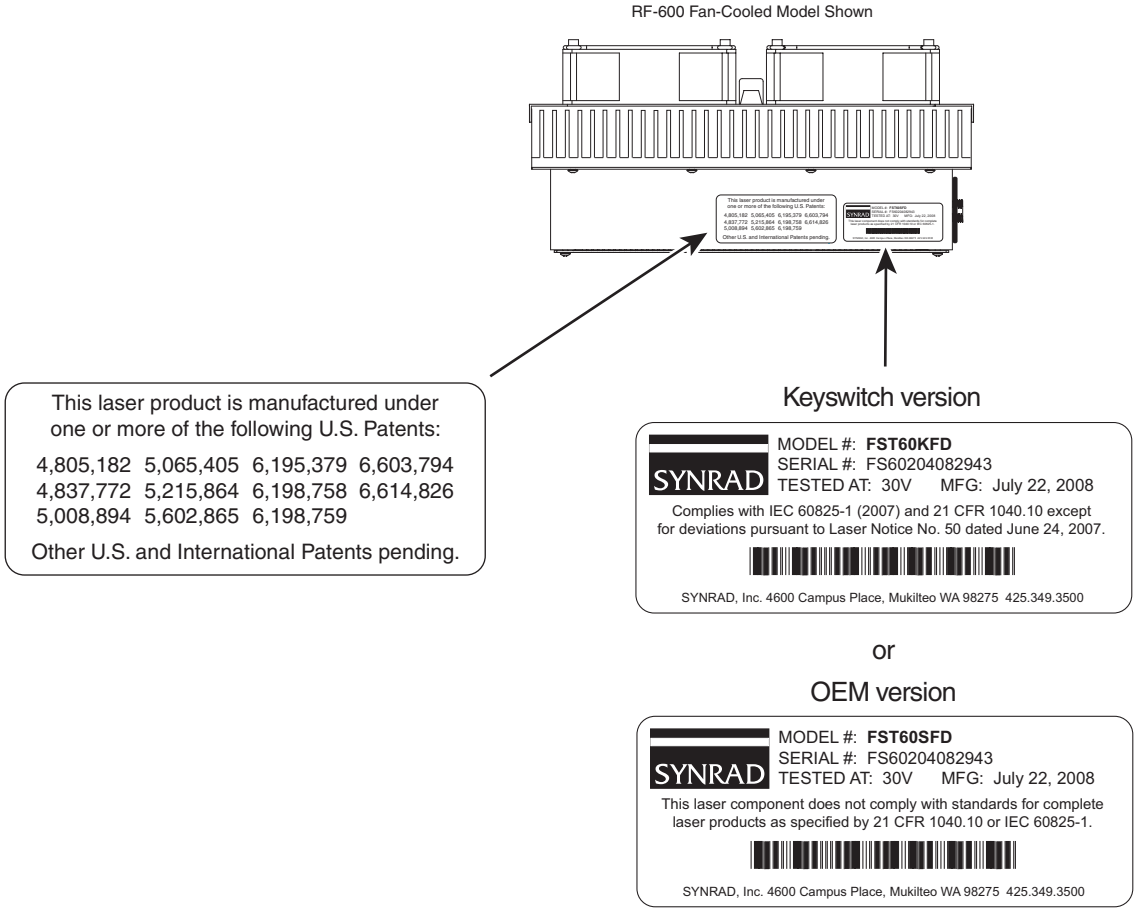

RF-600 Fan-Cooled Model Shown
This laser product is manufactured under one or more of the following U.S. Patents:
4,805,182 5,065,405 6,195,379 6,603,794
4,837,772 5,215,864 6,198,758 6,614,826
5,008,894 5,602,865 6,198,759
Other U.S. and International Patents pending.
Keyswitch version
SYNRAD
MODEL #: FST60KFD
SERIAL #: FS60204082943
TESTED AT: 30V MFG: July 22, 2008
Complies with IEC 60825-1 (2007) and 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 50 dated June 24, 2007.
SYNRAD, Inc. 4600 Campus Place, Mukilteo WA 98275 425.349.3500
or
OEM version
SYNRAD
MODEL #: FST60SFD
SERIAL #: FS60204082943
TESTED AT: 30V MFG: July 22, 2008
This laser component does not comply with standards for complete laser products as specified by 21 CFR 1040.10 or IEC 60825-1.
SYNRAD, Inc. 4600 Campus Place, Mukilteo WA 98275 425.349.3500

Figure 2 Firestar RF-600/RF-800/RF-1000 hazard label locations

laser safety

Agency compliance

The *Agency compliance* section includes subsections:

- Center for Devices and Radiological Health (CDRH) requirements
- Federal Communications Commission (FCC) requirements
- European Union (EU) requirements

SYNRAD lasers are designed, tested, and certified to comply with certain United States (U.S.) and European Union (EU) regulations. These regulations impose product performance requirements related to electromagnetic compatibility (EMC) and product safety characteristics for industrial, scientific, and medical (ISM) equipment. The specific provisions to which systems containing Firestar t-Series lasers must comply are identified and described in the following paragraphs. Note that compliance to CDRH, FCC, and EU requirements depends in part on the laser version selected—Keyswitch or OEM.

In the U.S., laser safety requirements are governed by the Center for Devices and Radiological Health (CDRH) under the auspices of the U.S. Food and Drug Administration (FDA) while radiated emission standards fall under the jurisdiction of the U.S. Federal Communications Commission (FCC). Outside the U.S., laser safety and emissions are governed by European Union (EU) Directives and Standards.

In the matter of CE-compliant laser products, SYNRAD, Inc. assumes no responsibility for the compliance of the system into which the product is integrated, other than to supply and/or recommend laser components that are CE marked for compliance with applicable European Union Directives.

Because OEM laser products are intended for incorporation as components in a laser processing system, they do not meet all of the Standards for complete laser processing systems as specified by 21 CFR, Part 1040 or EN 60825-1. SYNRAD, Inc. assumes no responsibility for the compliance of the system into which OEM laser products are integrated.

Center for Devices and Radiological Health (CDRH) requirements

Important Note: Firestar t-Series lasers are available in either Keyswitch or OEM versions.

Keyswitch models

Firestar t-Series keyswitch model lasers comply with requirements for Class IV laser products imposed by the Radiation Control for Health and Safety Act of 1968. Under this Act, the U.S. Food and Drug Administration (FDA) issued a performance standard in the *Code of Federal Regulations* (CFR) for laser products. This performance standard (21 CFR, Subchapter J, Part 1040.10) was developed to protect public health and safety by imposing requirements upon manufacturers of laser products to provide an indication of the presence of laser radiation, to provide the user with certain means to control radiation, and to assure that all personnel are adequately warned of potential hazards through the use of product labels and instructions.

Product features incorporated into the design of Firestar t-Series lasers to comply with CDRH requirements are integrated as panel controls or indicators, internal circuit elements, or input/output signal interfaces. Specifically, these features include a keyswitch (Keyswitch versions), lase and laser ready indicators, remote interlock for power on/off, a laser aperture shutter switch, and a five-second delay between power on and lasing. Incorporation of certain features is dependent on the laser version (Keyswitch or OEM). Table 1, *Class IV safety features*, indicates which features are available on t-Series lasers, the type and description of the feature, and if the feature is required by CDRH regulations.

laser safety

Agency compliance

OEM models

Firestar t-Series OEM lasers are OEM products intended for incorporation as components in laser processing systems. As supplied by SYNRAD, these lasers do not meet the requirements of 21 CFR, Subchapter J without additional safeguards. In the U.S., the Buyer of these OEM laser components is solely responsible for the assurance that the laser processing system sold to an end user complies with all laser safety requirements before the actual sale of the system. Under CDRH regulations, the Buyer must submit a report to the CDRH prior to shipping the system. In jurisdictions outside the U.S., it is the sole responsibility of the Buyer of these OEM components to ensure that they meet all applicable local laser safety requirements. In cases where the Buyer is also the end-user of the OEM laser product, the Buyer/end-user must integrate the laser so that it complies with all applicable laser safety standards as set forth above.

Federal Communications Commission (FCC) requirements

The United States Communication Act of 1934 vested the Federal Communications Commission (FCC) with the authority to regulate equipment that emits electromagnetic radiation in the radio frequency spectrum. The purpose of the Communication Act was to prevent harmful electromagnetic interference (EMI) from affecting authorized radio communication services. The FCC regulations that govern industrial, scientific, and medical (ISM) equipment are fully described in 47 CFR, Part 18, Subpart C.

SYNRAD's Firestar t-Series lasers are not yet fully tested to the requirements of 47 CFR, Part 18, Radiated and Conducted Emissions.

FCC information to the user

NOTE: The following FCC information to the user is provided to comply with the requirements of 47 CFR, Part 18, Section 213.

Interference Potential

In our testing, SYNRAD, Inc. has not discovered any significant electrical interference traceable to Firestar t-Series lasers.

System Maintenance

Ensure that all exterior covers are properly fastened in position.

Measures to Correct Interference

If you suspect that your Firestar laser interferes with other equipment, take the following steps to minimize this interference:

1. Use shielded cables to and from the equipment that is experiencing interference problems.
2. Ensure that the Firestar laser is properly grounded to the same electrical potential as the equipment or system it is connected to.

laser safety

Agency compliance

FCC caution to the user

The Federal Communications Commission warns the user that changes or modifications of the unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

European Union (EU) requirements

Important Note: Firestar t-Series lasers are available in either Keyswitch or OEM versions.

Laser safety standards

Under the Low Voltage Directive, 2006/95/EC, the European Norm (EN) document EN 60825-1 was developed to protect persons from laser radiation by imposing requirements upon manufacturers of laser products to provide an indication of laser radiation; to classify laser products according to the degree of hazard; to require both user and manufacturer to establish procedures so that proper precautions are adopted; to ensure adequate warning of the hazards associated with accessible radiation through signs, labels, and instructions; to improve control of laser radiation through protective features; and to provide safe usage of laser products by specifying user control measures.

Keyswitch models

Firestar t-Series keyswitch models are designed to comply with the requirements imposed by EN 60825-1 for Class IV laser products. Table 1, *Class IV safety features*, summarizes t-Series product features, indicating the type and description of features and whether those features are required by European Union regulations.

OEM models

Firestar t-Series OEM lasers are OEM products intended for incorporation as components in laser processing systems. As supplied by SYNRAD, these lasers do not meet the requirements of EN 60825-1 without additional safeguards. European Union Directives state that "OEM laser products which are sold to other manufacturers for use as components of any system for subsequent sale are not subject to this Standard, since the final product will itself be subject to the Standard." This means that Buyers of OEM laser components are solely responsible for the assurance that the laser processing system sold to an end-user complies with all laser safety requirements before the actual sale of the system. Note that when an OEM laser component is incorporated into another device or system, the entire machinery installation may be required to conform to EN 60204-1, *Safety of Machinery*; the Machinery Directive EN 98/37/EC; and/or any other applicable Standards. In cases where the Buyer is also the end-user of the OEM laser product, the Buyer/end-user must integrate the laser so that it complies with all applicable laser safety standards as set forth above.

laser safety

Agency compliance

Table 1 Class IV safety features

Feature	Location/Description	Required by: CDRH	Required by: EN60825-1
Keyswitch[1]	Rear panel control On/Off Keyswitch controls power to laser electronics. Key can not be removed from switch in the "On" position.	Yes	Yes
Shutter function[1]	Laser control Functions as a beam attenuator to disable RF driver/laser output when closed.	Yes	Yes
Shutter (SHT) indicator	Rear panel indicator (Blue) Illuminates blue to indicate shutter is open.	No	No
Ready (RDY) indicator	Rear panel indicator (Yellow) Indicates that laser has power applied and is capable of lasing.	Yes	Yes
Lase (LASE) indicator	Rear panel indicator (Red) Indicates that Firestar is actively lasing. Lase LED illuminates when the duty cycle of the Command signal is long enough to produce laser output.	Yes	Yes
Five second delay	Firestar circuit element Disables RF driver/laser output for five seconds after Keyswitch is turned to "On" or remote reset/start pulse is applied when Keyswitch is in "On" position.	Yes	No
Power fail lockout[1]	Firestar circuit element Disables RF driver/laser output if input power is removed then later reapplied (AC power failure or remote interlock actuation) while Keyswitch is in "On" position.	Yes	Yes
Remote Interlock	Rear panel connection Disables RF driver/laser output when a remote interlock switch on an equipment door or panel is opened.	Yes	Yes
Remote Interlock (INT) indicator	Rear panel indicator (Green/Red) Illuminates green when Remote Interlock circuitry is closed. Illuminates red when interlock circuitry is open.	No	No
Over temperature protection	Firestar circuit element Over temperature shutdown occurs if temperature of the laser tube rises above safe operating limits.	No	No
Temp (TMP) indicator	Rear panel indicator (Green/Red) Illuminates green when laser temperature is within operating limits, changing to red when thermal limits are exceeded.	No	No
Warning labels	Firestar exterior Labels attached to various external housing locations to warn personnel of potential laser hazards.	Yes	Yes

1 Keyswitch versions only

laser safety

Agency compliance

Electromagnetic interference standards

The European Union's Electromagnetic Compatibility (EMC) Directive, 2004/108/EC, is the sole Directive developed to address electromagnetic interference (EMI) issues in electronic equipment. In particular, the Directive calls out European Norm (EN) documents that define the emission and immunity standards for specific product categories. For Firestar t-Series lasers, EN 55011 and CISPR:11 define radiated and conducted RF emission limits while the generic Standards EN 61326 and EN 50082-1 define immunity requirements published by the International Electromechanical Commission (IEC).

SYNRAD's Firestar t-Series are not yet fully tested to the requirements of EMC Directive 2004/108/EC.

RoHS compliance

Firestar t-Series version D lasers meet the requirements of the European Parliament and Council Directive 2002/95/EC on the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment, as amended by Decision 2005/618/EC establishing maximum concentration values for certain hazardous substances in electrical and electronic equipment.

getting started

Use information in this section to prepare your Firestar t-Series laser for operation. The order of information presented in this section is the same as the order of tasks that you will need to perform. The best way to get your laser ready for operation is to start at *Inventory* and work your way through *Connecting*.

This section contains the following information:

- Introduction – introduces Firestar t-Series (t60/t80/t100) lasers, lists important features, and describes Firestar nomenclature.
- Unpacking – provides important information about shipping your t-Series laser.
- Inventory – displays and describes all components shipped with your laser.
- Mounting the RF power supply – describes how to attach the RF power supply to a mounting surface.
- Mounting the t-Series laser – describes how to attach the t60, t80, or t100 Laser Head to a mounting surface.
- Connecting – explains how to connect power, RF, and control cables as well as cooling connections for water-cooled models.

getting started

Introduction

Firestar® t-Series lasers are part of a new series of small-footprint lasers from SYNRAD featuring high power and excellent beam quality. The circular beam provides more accurate cutting and faster processing speeds than competing technologies. The compact Laser Head mounts easily to flatbed cutters, robotic arms, or gantry systems making integration into your production line simple and fast.

Firestar t-Series lasers are comprised of two major components—the t60, t80, or t100 Laser Head and the corresponding RF-600, RF-800, or RF-1000 RF power supply. Standard, or optional, RF and Interconnect cable lengths allow the RF power supply to be mounted away from the immediate laser processing and beam delivery area.

Firestar t-Series features include:

- Compact resonator design
- Excellent pulsing characteristics
- Fast rise/fall times (< 75 µs)
- Built-in "tickle" generator
- Color-coded LEDs mirror user outputs
- "Industrial-strength" ±5–24 VDC inputs and outputs
- Keyswitch fan- or water-cooled models available
- OEM (no Keyswitch/no shutter) air-, fan-, or water-cooled models available

Firestar nomenclature

Firestar Series lasers are divided into two distinct functional categories: Keyswitch and OEM models. In addition to a manual *Keyswitch*, all *Keyswitch*-equipped lasers include a manual shutter switch that allows the laser output aperture to be blocked. OEM lasers do not incorporate either a manual keyswitch or shutter assembly since they are primarily designed as components for integration into larger processing systems by the Original Equipment Manufacturer (OEM) or System Integrator who bears the responsibility for meeting the appropriate laser safety requirements for Class IV laser systems.

Model numbers

The last three characters in the Firestar model number serve to designate the functional category, cooling method, and model version. The functional category is indicated by either a "K" for Keyswitch or "S" (Switch-less) for OEM models. The next letter indicates the cooling method: "W" for water-cooled units, "F" for fan-cooled units, and "A" for air-cooled lasers (where the customer must provide the proper cooling via fans or blowers). The last letter in the model number indicates the current model version beginning with "B". For example, the model number FST60KFC designates that particular Firestar t60 laser as a Keyswitch, fan-cooled model. FST80SAD indicates a "D" version OEM, air-cooled t80 laser.

Note: Even though an SA Laser Head is air-cooled (meaning that the customer must cool the laser using some type of fan or blower to provide the appropriate airflow), the RF power supply is always supplied as a fan-cooled unit.

getting started

Unpacking

The *Unpacking* section includes subsections:

- Incoming inspection
- Packaging guidelines

Incoming inspection

Upon arrival, inspect all shipping containers for signs of damage. If you discover shipping damage, document the damage (photographically if possible), then immediately notify the shipping carrier and SYNRAD, Inc.

The shipping carrier is responsible for any damage occurring during transportation from SYNRAD, Inc. to your receiving dock.

Packaging guidelines

- To prevent equipment damage or loss of small components, use care when removing packaging materials.
- After unpacking, review the *Inventory* section and verify that all components are on hand.
- Do not lift or support the laser using the cooling fittings; lift the laser by the mounting feet or baseplate only.
- Save all shipping containers and packaging materials, including covers and plugs. Use these specialized packing materials when shipping the laser to another location.
- When packing a laser for shipment, be sure to remove all accessory items not originally attached to the laser including beam delivery components, cooling tubing, fittings, etc.
- Refer to *Packaging instructions* drawings in the Technical Reference chapter for details on packaging the Laser Head and RF power supplies using SYNRAD-supplied shipping materials.
- When shipping water-cooled lasers, remember to drain all cooling water from the laser and then cap open fittings to prevent debris from entering the coolant path.

getting started

Inventory

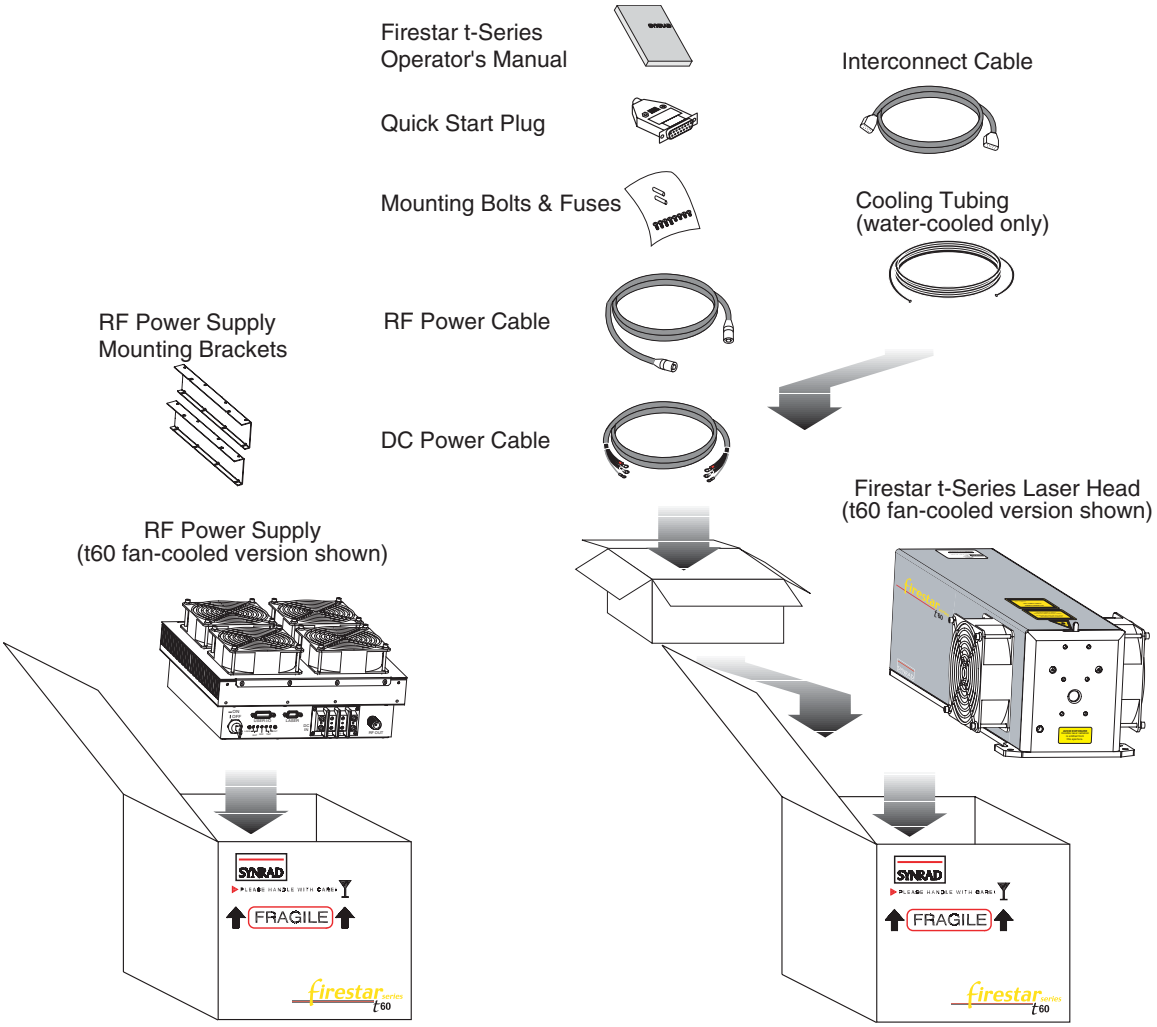


Figure 1-1 Firestar t-Series shipping box contents

Table 1-1 lists items included in the Firestar t-Series ship kit.

Table 1-1 Ship kit contents

Shipping Box Contents	Qty	Shipping Box Contents	Qty
SYNRAD Firestar t-Series Laser	1	Cooling Tubing (water-cooled only)	1
RF Power Supply	1	Mounting Bolts	3
Interconnect Cable	1	Firestar t-Series Operator's Manual	1
RF Power Cable	1	Spare 20 Ampere Fuse (not shown)	2
DC Power Cable	1	RF Mounting Brackets	2
Quick Start Plug (except SA models)	1	Final Test Report (not shown)	1

getting started

Inventory

Contents description

Each item listed in Table 1-1 is described below.

SYNRAD Firestar t-Series Laser – for cutting, welding, drilling, and marking a wide variety of products and materials.

RF Power Supply – converts the DC input voltage to a radio frequency (RF) output that drives the t-Series Laser Head.

Interconnect Cable – carries DC fan power and LED drive signals from the RF power supply to the Laser Head.

RF Power Cable – provides RF energy from the RF power supply to the Firestar t-Series Laser Head.

DC Power Cable – carries DC power from the DC power supply to the RF power supply.

Quick Start Plug (except SA models) – connects to Firestar's *User I/O* connector. Jumpers are built into the plug to enable Firestar's shutter and remote interlock circuits for initial start-up and testing.

Cooling Tubing (water-cooled only) – carries cooling water from the chiller to the laser/RF power supply and back. This black polyethylene tubing is 1/2-inch O.D. by 30 feet and must be cut to length.

Mounting Bolts – 1/4–20 × 5/8" bolts fasten Firestar to your mounting surface.

Firestar t-Series Operator's Manual – provides setup, operation, and maintenance information for your Firestar t-Series laser.

Spare 20 Ampere Fuse (not shown) – fast blow fuse protects Firestar's internal circuitry.

RF Mounting Brackets – for fastening the RF power supply to your mounting surface.

Bracket Mounting Screws (RF-1000 only) – Eight each 3/8" screws and washers for attaching RF-1000 mounting brackets.

Final Test Report (not shown) – contains data collected during the laser's final pre-shipment test.

getting started

Mounting the RF power supply

The *Mounting the RF power supply* section includes subsections:

- Mounting guidelines
- Attaching mounting brackets
- Mounting the RF supply

The RF power supply is shipped with its mounting brackets removed. Follow the steps described below to attach mounting brackets and fasten the RF supply to your mounting surface.

Mounting guidelines

- Mount water-cooled RF power supplies vertically, or on a vertical surface, to prevent condensation from pooling on upper or lower covers and dripping onto electrical components.
- Outline and mounting dimensions for both RF-600 and the RF-800 RF power supplies are identical; the RF-1000 RF power supply has a slightly larger footprint.
- The RF power supply must be mounted within cable length, approximately 6 feet (2 meters), of the Laser Head.
- When mounting RF power supplies vertically using the optional 8–32 UNC threaded holes (on the ends of the heatsink chassis), the RF power supply must be supported on both upper and lower ends.
- To ensure optimum system performance, t-Series Laser Heads and RF power supplies are tested and shipped as matched sets. Interchanging these components may result in decreased laser performance. RF cables may be interchanged as long as the cable length is identical.
- Air- or fan-cooled units must have at least 2.25" (57.2 mm) of unobstructed clearance between the outside edge of the cooling fan housing and any enclosure or mounting surface to allow for proper airflow.

Attaching mounting brackets

To attach RF mounting brackets, refer to Figure 1-2 and perform the following steps:

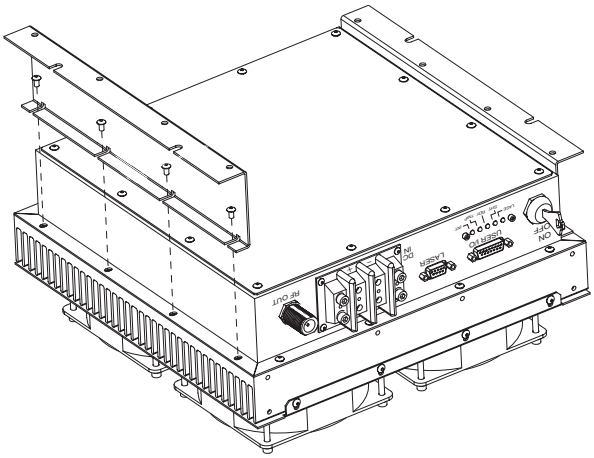


Figure 1-2 Attaching mounting brackets

getting started

Mounting the RF power supply

1 Carefully place the RF power supply on a bench or table so that it is resting on the cooling fans.

2 Locate the side of the RF power supply where the cooling fins are exposed. Use a 5/64" hex wrench to remove the four button head screws fastening the power supply section to the cooling fins.

3 Orient the mounting bracket as shown in Figure 1-2 with the open part of the channel facing out and the wide mounting foot facing up.

4 (RF-600/RF-800) Insert the button head screws removed in Step 2 through the bracket mounting holes into the threaded holes of the power supply section.

(RF-1000) Locate the 3/8" long button head screws and washers shipped with the RF-1000 mounting brackets. Place a washer over each screw and insert the screws into the threaded holes of the power supply section.

5 Tighten all screws with a hex wrench being careful not to overtighten them.

6 Repeat Steps 2 through 5 for the opposite side.

7 Carefully turn the RF power supply over so that it is sitting on its mounting brackets.

Mounting the RF supply

To fasten the RF power supply to your mounting surface, refer to Figure 1-3 and perform the following steps:

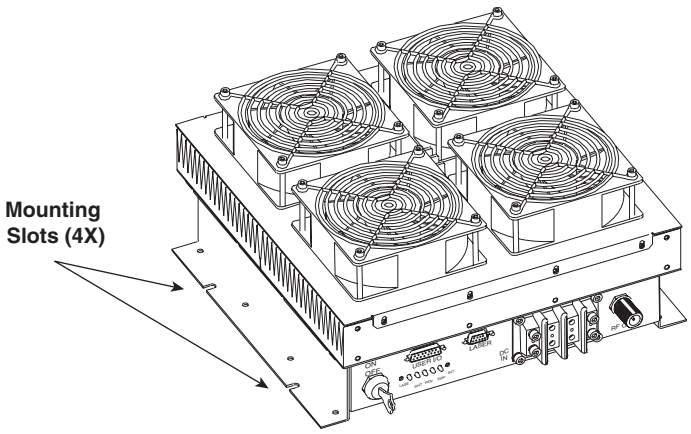


Figure 1-3 Mounting the RF-600/RF-800/RF-1000

1 Refer to *RF-600/RF-800 package outline drawing* or *RF-1000 package outline drawing* in the Technical Reference chapter for dimensions and then drill and tap four holes into your mounting surface. These holes should correspond to the mounting slots located on the mounting brackets.

2 Position the RF power supply so that the holes in the mounting brackets line up with the tapped holes in the mounting surface.

3 Insert four bolts through the mounting brackets into the threaded holes of the mounting surface. Turn the screws by hand until the threads engage.

4 Tighten all four bolts to a torque of 6 ft lb_f (8 N m) maximum.

getting started

Mounting the t-Series laser

The *Mounting the t-Series laser* section includes subsections:

- Mounting guidelines
- Mounting the Laser Head

Firestar's base plate is designed so that the laser is easily mounted to either vertical or horizontal surfaces using only three fasteners. Three ball bearing "feet" pressed into Firestar's base plate eliminate any possible distortion of the laser tube caused by variations in the flatness of the surface on which the Laser Head is mounted. Refer to the appropriate Firestar t60, t80, or t100 package outline drawing in the Technical Reference chapter for Firestar mounting locations and dimensions. Read through the mounting sections below to determine which set of mounting holes are required for your application.

Mounting guidelines

Caution possible equipment damage	SYNRAD does not recommend mounting lasers in a vertical "head-down" or "tail-down" orientation. If you must mount your laser in this manner, please contact the factory for limitations as a vertical orientation increases the risk of damage to the laser's output optic.

- Package outline and mounting hole dimensions for Firestar t60, t80, and t100 Laser Heads are identical, except for cooling fan locations. The cooling fans on fan-cooled t80/t100 Laser Heads are mounted near the center of the chassis; t60 cooling fans are mounted near the front of the chassis.
- Mount the Laser Head within cable length, approximately 6 feet (2 meters), of the RF power supply.
- To ensure optimum system performance, t-Series Laser Heads and RF power supplies are tested and shipped as matched sets. Interchanging these components may result in decreased laser performance. RF cables may be interchanged as long as the cable length is identical.
- Air- or fan-cooled units must have at least 2.25" (57.2 mm) of unobstructed clearance between the outside edge of the cooling fan housing and any enclosure or mounting surface to allow for proper airflow.

Mounting the Laser Head

When mounting Firestar t-Series Laser Heads, you can choose to fasten from above, into your mounting surface, or from below, into the laser's base plate.

Fastening from above

To fasten your t-Series laser to a mounting surface from above, perform the following steps:

1. Refer to the appropriate outline and mounting drawing for dimensions and then drill and tap three 1/4–20 UNC holes into your mounting surface. These hole locations should correspond to the two slots labeled "A" and the thru hole labeled "B" shown in Figure 1-4.

Mounting the t-Series laser

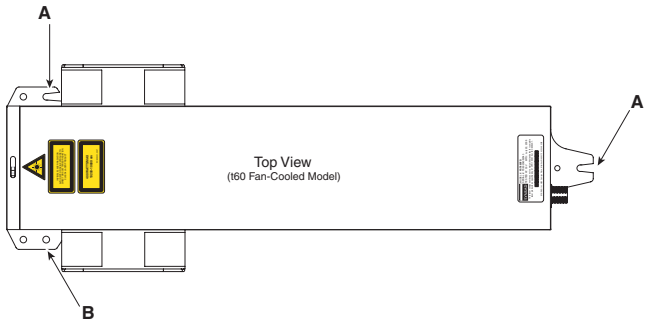


Figure 1-4 Fastening from above

2 Place Firestar on the mounting surface so that slots “A” and hole “B” on the base plate line up with the tapped holes in the mounting surface.

3 Insert 1/4–20 × 5/8" UNC capscrews through Firestar’s base plate into the threaded holes of the mounting surface. Turn the screws by hand until the threads engage.

4 Tighten all three capscrews to a torque of 5 ft lb_f (7 N m). Do ***not*** exceed a torque of 6 ft lb_f (8 N m) as the base plate may be damaged.

Fastening from below

To fasten your t-Series laser to a mounting surface from below, perform the following steps:

1 Refer to the appropriate outline and mounting drawing for dimensions and then drill three 0.261" holes into your mounting surface. Hole locations should correspond to the threaded holes labeled “C” shown in Figure 1-5.

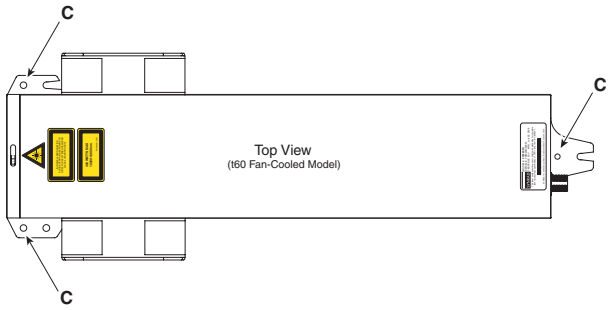


Figure 1-5 Fastening from below

2 Place Firestar on the mounting surface so that the threaded holes on the base plate (labeled “C” in Figure 1-5) line up with the holes drilled through the mounting surface.

3 Insert 1/4–20 × 5/8" UNC capscrews through the mounting surface into the threaded holes of Firestar’s base plate. Turn the screws by hand until the threads engage.

4 Tighten all three capscrews to a torque of 5 ft lb_f (7 N m). Do ***not*** exceed a torque of 6 ft lb_f (8 N m) as the base plate may be damaged.

getting started

Connecting

The *Connecting* section includes subsections:

- Water-cooled connections
- OEM air-cooled connections
- Electrical connections
- Control connections

Water-cooled connections

Note: If your Laser Head is fan-cooled, then skip to the *Electrical connections* section.

Read *Guidelines for cutting and installing tubing* before installing any cooling tubing and then make sure to connect the cooling system exactly as described for your particular laser.

Guidelines for cutting and installing tubing

- Cut tubing lengths generously to allow for trimming.
- Cut tubing squarely; diagonal cuts may not seal properly. Carefully trim any burrs if the cut is "ragged".
- Avoid excessive stress on fittings; create gentle bends when routing tubing close to connectors. Excessive stress from sharp bends will compromise the sealing properties of the fitting.
- Never allow the tubing to kink, since kinking severely restricts coolant flow.
- Push tubing completely into the fitting, then pull the tubing to verify that it is locked into place. Tubing extends into the fitting approximately 7/8 of an inch.
- If tubing must be disconnected from a fitting, first push and hold the tubing slightly into the fitting. Next push the white fitting ring evenly towards the fitting, and then pull the tubing free.
- After disconnecting tubing from a fitting, trim 1/2" (57.2 mm) from its end before reconnecting. Trimming the end of the tubing before reconnecting the fitting provides an undisturbed sealing surface.

Laser cooling fittings

If your integrated laser application uses metric cooling tubing, we recommend the installation of tubing adaptors to convert the laser's *WATER IN* and *WATER OUT* fittings from 1/2-inch tubing to 12-mm metric tubing. These tubing adaptors are available from many tubing and fitting manufacturers.

If, for any reason, you must remove and then reinstall the threaded *WATER IN* and *WATER OUT* cooling fittings on the laser or the RF power supply, do not overtighten them. When installing new fittings, wrap the threads with teflon tape and then carefully tighten the fittings until they are just snug enough to prevent water leakage.

Chiller preparation guidelines

- You must provide fittings that will adapt the laser's 1/2-inch O.D. polyethylene cooling tubing to your chiller's Inlet and Outlet ports. These fittings can be either "quick disconnect" or compression type fittings.
- Because Firestar's cooling tubing is specified in inch sizes, the use of metric tubing fittings is discouraged unless you have installed the appropriate inch-to-metric tubing adaptors. The use of metric fittings on inch size tubing will lead to coolant leaks or may allow the pressurized tubing to blow-off the fitting.

Coolants

SYNRAD recommends that the laser's cooling fluid contain at least 90% water (distilled or tap) by volume. In closed-loop systems, use a corrosion inhibitor/algaecide such as Optishield® Plus or equivalent. Avoid glycol-based additives because they reduce the coolant's heat capacity and high concentrations may affect power stability. For SYNRAD lasers, the minimum coolant setpoint is 18 °C (64 °F) so glycol is not necessary unless the chiller is subjected to freezing temperatures. In applications where biocides containing chlorides are used, concentrations should not exceed 25 parts per million (PPM). Maintain a coolant pH level above 7.0. We recommend the installation of a filter on the chiller's return line, especially in areas where water hardness is a problem. Firestar t-Series lasers incorporate the following wetted materials in the coolant path—aluminum, brass, copper, Delrin®, PBT, polyethylene, stainless steel, and Viton®.

Setting coolant temperature

Choosing the correct coolant temperature is important to the proper operation and longevity of your laser. When coolant temperature is lower than the dew point (the temperature at which moisture condenses out of the surrounding air), condensation forms inside the laser housing leading to failure of laser electronics as well as damage to optical surfaces.

The greatest risk of condensation damage occurs when the laser is in a high heat/high humidity environment and the chiller's coolant temperature is colder than the dew point of the surrounding air or when the system is shut down, but coolant continues to flow through the laser for extended periods of time.

The chiller's temperature setpoint must always be set above the dew point temperature. In cases where this is not possible within the specified coolant temperature range of 18 °C to 22 °C (64 °F to 72 °F), then the following steps MUST be taken to reduce the risk of condensation damage.

- Stop coolant flow when the laser is shut down.
- Increase coolant flow by an additional 1.0 GPM. Do not exceed a coolant pressure of 60 PSI.
- Air-condition the room or the enclosure containing the laser.
- Install a dehumidifier to reduce the humidity of the enclosure containing the laser.

Table 1-2 provides dew point temperatures for a range of air temperature and relative humidity values. Remember that the laser's coolant temperature must be set above the dew point temperatures shown in the chart, but for best results and performance do not exceed a coolant temperature of 22 °C (72 °F).

Connecting

Caution
possible equipment damage

Operating the laser at coolant temperatures above 22 °C (72 °F) may result in decreased performance and/or premature failure of electronic components.

Table 1-2 Dew point temperatures

Dew Point Temperature Chart °F (°C)

	Relative Humidity (%)															
	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
Air Temp °F (°C)																
60 (16)	—	—	—	32 (0)	36 (2)	39 (4)	41 (5)	44 (7)	46 (8)	48 (9)	50 (10)	52 (11)	54 (12)	55 (13)	57 (14)	59 (15)
65 (18)	—	—	33 (1)	37 (3)	40 (4)	43 (6)	46 (8)	48 (9)	51 (11)	53 (12)	55 (13)	57 (14)	59 (15)	60 (16)	62 (17)	64 (18)
70 (21)	—	33 (1)	37 (3)	41 (5)	45 (7)	48 (9)	51 (11)	53 (12)	56 (13)	58 (14)	60 (16)	62 (17)	64 (18)	65 (18)	67 (19)	69 (21)
75 (24)	—	37 (3)	42 (6)	46 (8)	49 (9)	52 (11)	55 (13)	58 (14)	60 (16)	62 (17)	65 (18)	67 (19)	68 (20)	70 (21)	72 (22)	73 (23)
80 (27)	35 (2)	41 (5)	46 (8)	50 (10)	54 (12)	57 (14)	60 (16)	62 (17)	65 (18)	67 (19)	69 (21)	71 (22)	73 (23)	75 (24)	77 (25)	78 (26)
85 (29)	40 (4)	45 (7)	50 (10)	54 (12)	58 (14)	61 (16)	64 (18)	67 (19)	70 (21)	72 (22)	74 (23)	76 (24)	78 (26)	80 (27)	82 (28)	83 (28)
90 (32)	44 (7)	50 (10)	54 (12)	59 (15)	62 (17)	66 (19)	69 (21)	72 (22)	74 (23)	77 (25)	79 (26)	81 (27)	83 (28)	85 (29)	87 (31)	88 (31)
95 (35)	48 (9)	54 (12)	59 (15)	63 (17)	67 (19)	70 (21)	73 (23)	76 (24)	79 (26)	81 (27)	84 (29)	86 (30)	88 (31)	90 (32)	92 (33)	93 (34)
100 (38)	52 (11)	58 (14)	63 (17)	68 (20)	71 (22)	75 (24)	78 (26)	81 (27)	84 (29)	86 (30)	88 (31)	91 (33)	93 (34)	95 (35)	97 (36)	98 (37)

To use Table 1-2, look down the *Air Temp* column and locate an air temperature in Fahrenheit or Celsius (°C values are shown in parentheses) that corresponds to the air temperature in the area where your laser is operating. Follow this row across until you reach a column matching the relative humidity in your location. The value at the intersection of the *Air Temp* and *Relative Humidity* columns is the *Dew Point* temperature in °F (or °C). The chiller's temperature setpoint must be set above the dew point temperature. For example, if the air temperature is 85 °F (29 °C) and the relative humidity is 60%, then the dew point temperature is 70 °F (21 °C). Adjust the chiller's temperature setpoint to 72 °F (22 °C) to prevent condensation from forming inside the laser.

Cooling tubing connections

Because changes in laser temperature can cause fluctuations in output power, coolant must flow through the Laser Head before it flows through the RF power supply. The following procedure will guide you in configuring the most efficient cooling system. Please connect your system exactly as described below.

To connect cooling tubing, refer to Figure 1-6 and perform the following steps. The numbered items in Figure 1-6 correspond to the step numbers in the following procedure.

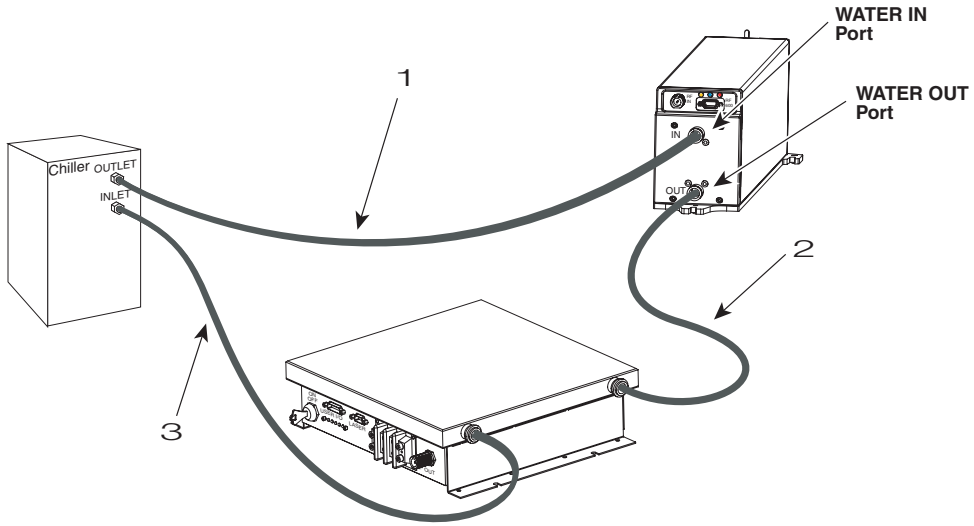


Figure 1-6 Firestar t-Series cooling connections

1 Cut and connect a length of tubing to fit between the chiller's Outlet port and the upper *WATER IN* port on the rear of the Firestar t-Series laser.

2 Cut and connect a length of tubing to fit between the lower *WATER OUT* port on the rear of the laser and a cooling port on the RF power supply.

Note: When plumbing an RF-1000 RF power supply, connect cooling tubing between the t100's *WATER OUT* port and the center cooling port on the RF-1000 RF power supply.

3 Cut and connect a length of tubing to fit between the other RF power supply cooling port and the chiller's Inlet port.

Note: When plumbing an RF-1000 RF power supply, connect cooling tubing between the outer cooling port on the end of the RF-1000 RF power supply and the chiller's Inlet port.

Caution possible equipment damage	Inlet cooling water temperature must always be maintained above the dew point to prevent condensation and water damage to your Firestar laser.

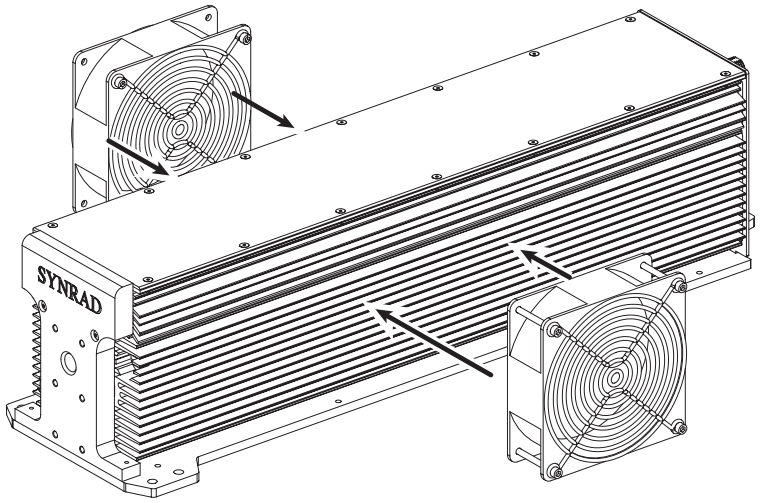
Connecting

4 Turn on the chiller and adjust the temperature setpoint to 18 °C to 22 °C. Regulate coolant flow to 0.75–2.0 GPM (2.8–7.6 lpm) at less than 60 PSI (4.14 bar) of pressure.

5 Closely examine all cooling connections and verify that there are no leaks.

OEM air-cooled connections (SA models)

OEM air-cooled lasers (SA models) are shipped without cooling fans so customers must provide some type of cooling to prevent the Laser Head from overheating. For t60 Laser Heads, SYNRAD recommends an airflow of at least 130 cubic feet per minute (CFM) for each of the two required fans. For t80/t100 lasers, you must provide at least 195 CFM per fan. Figure 1-7 illustrates the fan placement necessary to keep the laser's heat sink temperature below 50 °C (122 °F). To provide proper airflow, cooling fans should have a diameter of approximately 4.5–5" (114–127 mm) and have at least 2.25" (57.2 mm) of unobstructed clearance between the outside edge of the cooling fan housing and any mounting surface or enclosure.



Fans should be mounted so that they are centered both horizontally and vertically on each side of the OEM t60 laser

Figure 1-7 Recommended t-Series cooling fan locations

Two +24 VDC outputs (0.75 A max. each) on the SA's side-mounted DB-9 are available to power customer-supplied cooling fans. Refer to *DB-9 connections* in the Technical Reference chapter for details.

Caution
possible equipment damage

The +24 VDC outputs described above are not fused or electrically protected. Do not short these pins to ground; the control board will be damaged.

Connecting

SYNRAD recommends side-mounted cooling fans for t-Series lasers, but for t60 lasers only, a single rear-mounted cooling fan is feasible. Figure 1-8 illustrates the rear-cooling concept. Please review the guidelines below to ensure that your implementation provides enough airflow to prevent damage to the laser. The cooling fan must supply at least 300 CFM in order to keep the t60 laser's heat sink temperature below 50 °C (122 °F). Establishing significant airflow evenly over the entire surface area of the laser chassis is vitally important to the performance and longevity of the laser.

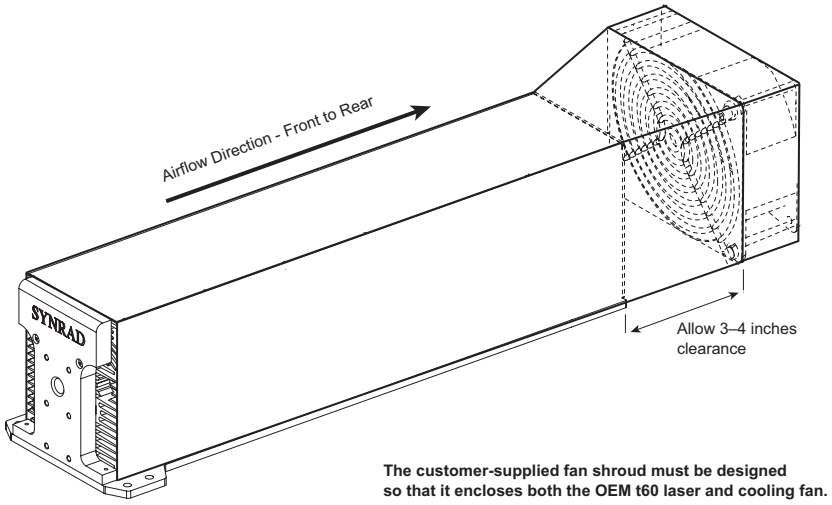

Airflow Direction - Front to Rear
SYNRAD
Allow 3–4 inches clearance
The customer-supplied fan shroud must be designed so that it encloses both the OEM t60 laser and cooling fan.

Figure 1-8 Rear-mounted t60 cooling

Guidelines for t60 rear cooling

- The cooling shroud must be designed so that it encloses the full length of both the t60 laser and the cooling fan.
- The shroud must fit snugly against the laser's cooling fins so that cooling air is ducted between the fins and not around them.
- To allow proper heat dissipation, the shroud must be open at the front to allow cooling air to flow away from the laser.
- Allow 3–4" (76–102 mm) of clearance between the front of the cooling fan and the rear of the laser.
- Install the cooling fan so the airflow direction is from the front of the laser towards the rear of the laser.
- To provide proper airflow, the cooling fan should have a diameter of approximately 4.5–5" (114–127 mm) and must supply an airflow of at least 300 CFM distributed evenly over the length and width of the t60's cooling fins.

getting started

Connecting

Electrical connections

The following procedures describe how to complete electrical connections to t-Series lasers.

Caution possible equipment damage	Do not connect or disconnect the *Interconnect* cable while DC power is applied to the RF power supply. This may damage the RF supply's internal circuitry. Always remove DC power before connecting or disconnecting cables from the laser or RF power supply.

Interconnect cable

The *Interconnect* cable carries cooling fan power and indicator signals between the RF power supply and Laser Head. To connect the *Interconnect* cable, refer to Figure 1-9 and perform the following steps. The numbered items in Figure 1-9 correspond to the step numbers in the following procedure.

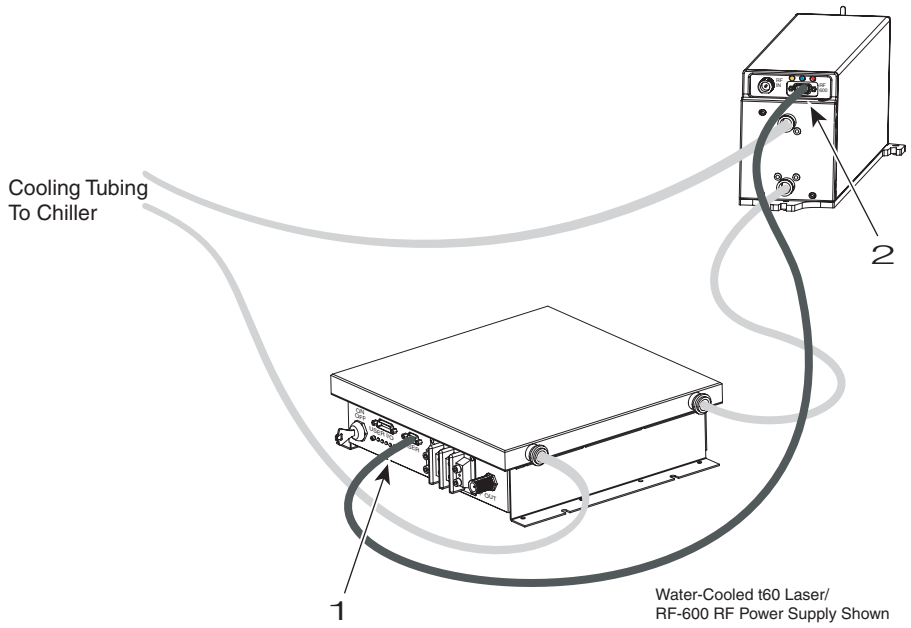


Figure 1-9 Firestar t-Series Interconnect cable connections

1 Locate the *Interconnect* cable in the ship kit and connect one end of the *Interconnect* cable to the DB-9 connector labeled *Laser* on the RF power supply.

2 Connect the other end to the DB-9 connector labeled *RF Supply* on the Laser Head's rear panel.

Note: The *Interconnect* cable for Firestar t60/t80 lasers is available in 2 meter (6.6 ft), 5 m (16.4 ft), and 8 m (26.3 ft) lengths while the t100 *Interconnect* cables are available in 2 meter (6.6 ft), 5 m (16.4 ft), and 11 m (36.1 ft) lengths. The standard *Interconnect* cable length is 2 meters.

The minimum bend radius for the *Interconnect* cable must be greater than 3.0 inches (76.2 mm).

Connecting

RF Power cable

The *RF Power* cable carries radio frequency (RF) power from the RF power supply to the Laser Head. To connect the *RF Power* cable, refer to Figure 1-10 and perform the following steps. The numbered items in Figure 1-10 correspond to the step numbers in the following procedure.

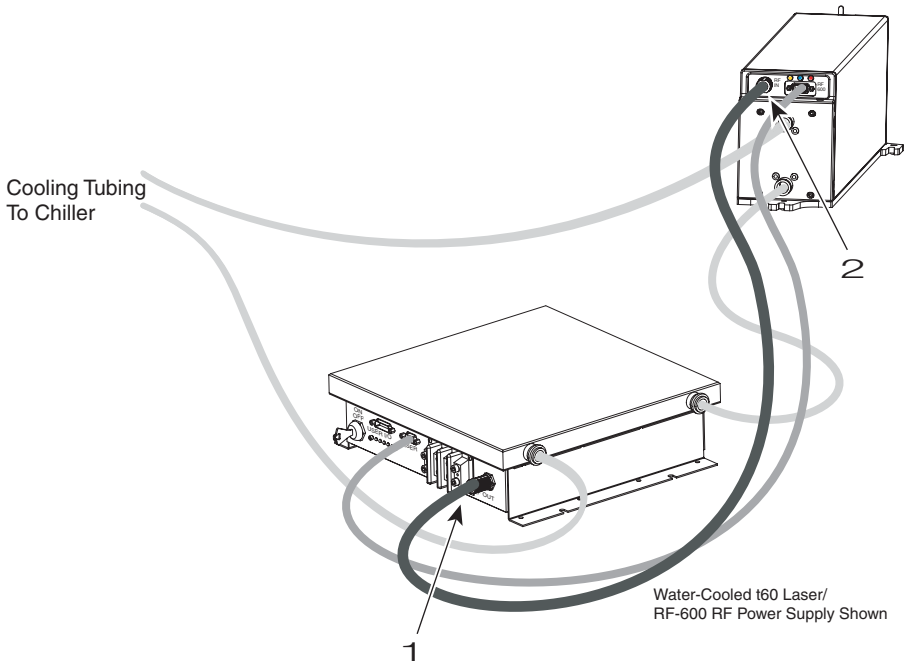


Figure 1-10 Firestar t-Series RF Power cable connections

1. Locate the *RF Power* cable in the ship kit and thread one end of the RF connector onto the *RF Out* connector on the RF power supply.
2. Thread the other end of the *RF Power* cable onto the *RF In* connector on the Laser Head.
3. Tighten the retaining sleeves as tight as possible by hand.

Important Note: When RF cables longer than standard length are required, they must be specified at the time the laser is ordered. For pre-existing systems, longer cables can be retrofitted only after the laser and RF power supply are returned to SYNRAD for re-tuning.

Note: Firestar t60/t80 *RF Power* cables are available in 2 meter (6.6 ft), 5 m (16.4 ft), and 8 m (26.3 ft) lengths while t100 *RF Power* cables are available in 2 meter (6.6 ft), 5 m (16.4 ft), and 11 m (36.1 ft) lengths. The standard RF cable length is 2 meters. Using RF cable lengths other than those specified will severely degrade laser performance and may damage the RF driver.

For all *RF Power* cables, the minimum bend radius must be greater than 6.0 inches (152 mm). For best results, SYNRAD recommends designing your laser processing application to minimize repeated flexing of the RF cable during normal operation.

Connecting

DC power supply

RF-600/RF-800 *DC Power* cables are manufactured with #6 AWG wire and measure 2 meters (6.6 feet) in length. RF-1000 *DC Power* cables are also 2 meters in length, but are manufactured using larger diameter (#4 AWG) wire due to the higher amperage requirement. We do not recommend shortening or lengthening these cables because specialized crimping equipment is required to properly affix the terminal lugs.

The minimum bend radius for RF-600/RF-800 *DC Power* cables must be greater than 2.6 inches (66.8 mm), while RF-1000 power cables must have a bend radius greater then 3.3 inches (83.0 mm).

Important Note: If you choose to lengthen the *DC Power* cables (instead of AC wiring), you must calculate the additional voltage drop to ensure that the correct voltage is available at RF supply input terminals under full-load conditions. Depending on the additional length required, you may need to increase wire size to a larger diameter gauge.

Caution
possible equipment damage

Do not reverse polarity when connecting the *DC Power* cable to the RF power supply. Reversed DC polarity may damage the RF supply's internal circuitry. Carefully follow directions to ensure that DC cable leads are properly connected to the correct DC input terminals on the RF power supply.

Note: The negative (–) side of the DC input to the laser is internally connected so that the laser chassis serves as DC power ground. You should isolate the laser's DC power supply so that the only grounded connection is at the laser. Alternatively, you can mount the laser chassis on an insulating pad or film in order to electrically isolate the laser when other equipment is grounded to the laser's DC power supply.

DC-6 (t60/RF-600)

The RF-600 RF power supply requires a DC power supply capable of supplying 30 VDC at 45 A max. We recommend the SYNRAD DC-6 power supply (shown below). AC input requirements for the DC-6 are 85–264 VAC, single-phase (1Ø), 18 A max, 47–440 Hz. To connect the DC-6 power supply, refer to Figure 1-11 and perform the following steps:

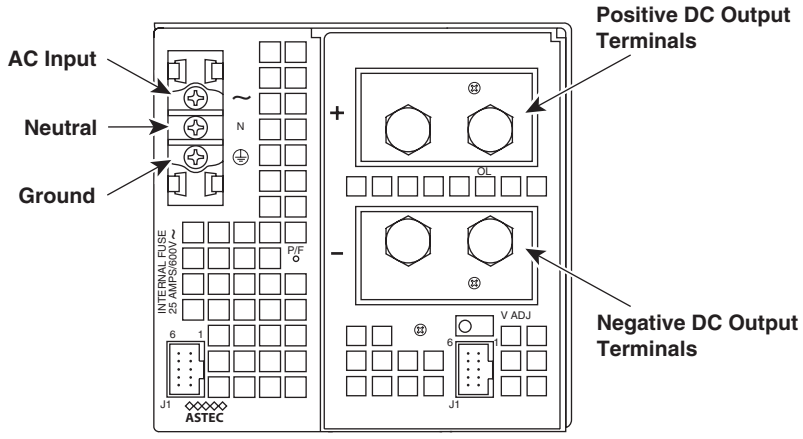


Figure 1-11 DC-6 DC power supply

Connecting

1 Verify that AC power to the DC power supply is physically locked out or disconnected.

2 Locate the *DC Power* cable in the ship kit. The *DC Power* cable is approximately seven feet (2 meters) long with connection lugs on both ends.

3 Locate the 30 VDC output terminals on the DC-6 output section and connect the black (–) cable to one of the negative (–) 30 VDC output terminals on the DC-6.

4 Attach the other end of the black cable to the negative (–) DC input terminal on the RF-600.

5 Connect one end of the red cable to one of the positive (+) 30 VDC output terminals on the DC-6.

6 Attach the other end of the red cable to the positive (+) DC terminal on the RF-600.

Note: Because AC input connections and requirements vary from facility to facility, customers must provide the AC power cable or wiring.

7 Locate the AC input section on the DC-6 DC power supply and connect the neutral AC wire, typically white, to the AC neutral input terminal labeled "N".

8 Connect the hot AC wire, typically black, to the AC line input terminal labeled "~".

9 Connect the ground wire, typically green, to the input terminal labeled with the ground symbol.

DC-36 (t80/RF-800)

The RF-800 RF power supply requires a DC power supply capable of supplying 36 VDC at 55 A max. We recommend the SYNRAD DC-36 power supply (shown below). AC input requirements for the DC-36 are 160–264 VAC, single phase (1Ø), 13 A max, 47–63 Hz. To connect the DC-36 power supply, refer to Figure 1-12 and perform the following steps:

Important Note: The DC-36 DC power supply is only rated to provide the necessary voltage and current at input voltages between 160–264 VAC. The supply is derated to 1500 W at AC input voltages below 160 VAC.

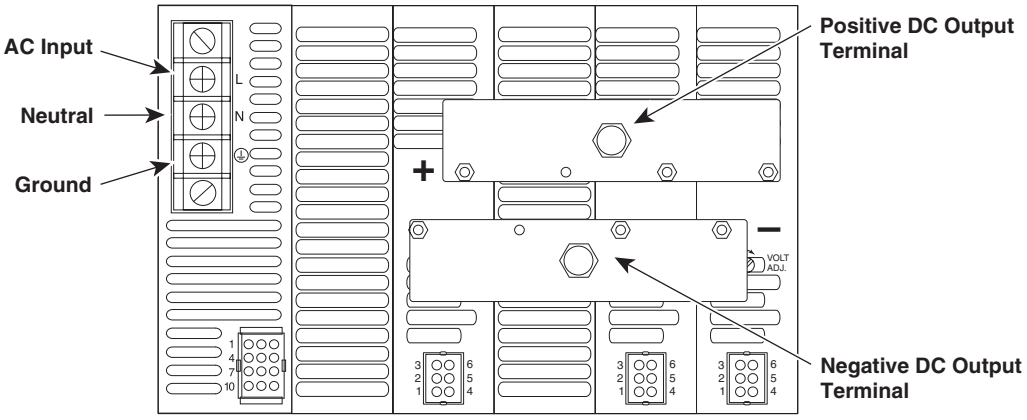


Figure 1-12 DC-36 DC power supply

getting started

Connecting

1 Verify that input AC power to the DC power supply is physically locked out or disconnected.

2 Locate the *DC Power* cable in the ship kit. The *DC Power* cable is approximately seven feet (2 meters) long with connection lugs on both ends.

3 Locate the 36 VDC output terminals on the DC-36 output section and connect the black (–) cable to the negative (–) 36 VDC output terminal.

4 Attach the other end of the black cable to the negative (–) DC input terminal on the RF-800.

5 Connect one end of the red cable to the positive (+) 36 VDC output terminal on the DC-36.

6 Attach the other end of the red cable to the positive (+) DC terminal on the RF-800.

Note: Because AC input connections and requirements vary from facility to facility, customers must provide the AC power cable or wiring.

7 Locate the AC input section on the DC-36 DC power supply and connect the neutral AC wire, typically white, to the AC neutral input terminal labeled "N".

8 Connect the hot AC wire, typically black, to the AC line input terminal labeled "L".

9 Connect the ground wire, typically green, to the input terminal labeled with the ground symbol.

DC-100 (t100/RF-1000)

The RF-1000 RF power supply requires a DC power supply capable of supplying 30 VDC at 75 A max. We recommend the SYNRAD DC-100 DC power supply (shown below). AC input requirements for the DC-100 are 180–264 VAC, three phase (3Ø), 13 A max, 47–63 Hz. Alternatively, the DC-100 power supply can be wired for single-phase operation (16 A max) in cases where three-phase voltage is not available. To connect the DC-100 power supply, refer to Figure 1-13 and perform the following steps:

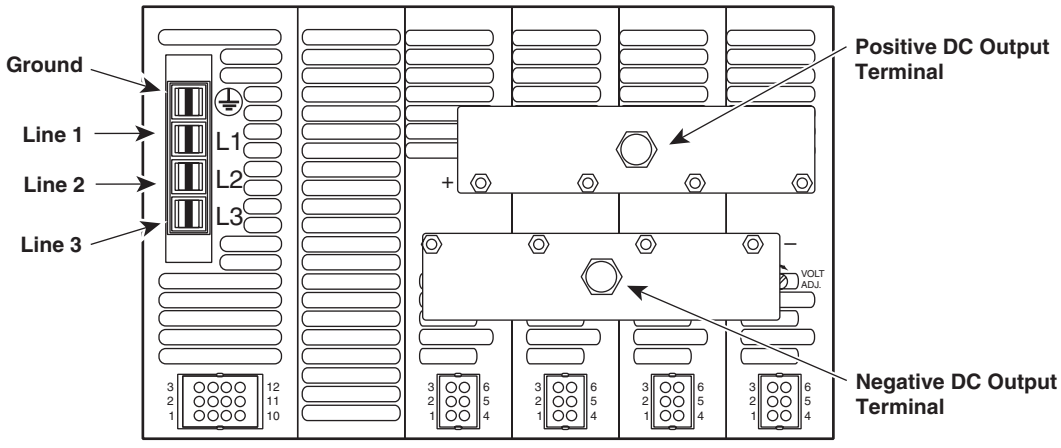


Figure 1-13 DC-100 DC power supply

Connecting

1. Verify that input AC power to the DC power supply is physically locked out or disconnected.
2. Locate the *DC Power* cable in the ship kit. The *DC Power* cable is approximately seven feet (2 meters) long with connection lugs on both ends.
3. Locate the 30 VDC output terminals on the DC-100 output section and connect the black (–) cable to the negative (–) 30 VDC output terminal.
4. Attach the other end of the black cable to the negative (–) DC input terminal on the RF-1000.
5. Connect one end of the red cable to the positive (+) 30 VDC output terminal on the DC-100.
6. Attach the other end of the red cable to the positive (+) DC terminal on the RF-1000.

Note: Because AC input connections and requirements vary from facility to facility, customers must provide the AC power cable or wiring. The DC-100 power supply does include a four-terminal input connector and crimp pins sized for 10–12 AWG wire.

Three-phase AC operation

1. Verify that input AC power to the DC power supply is physically locked out or disconnected.
2. Connect the ground (earth) wire, typically green, to the black input connector so that it aligns with the input terminal labeled with the ground symbol.
3. Connect the first AC three-phase hot wire, typically black, to the black input connector so that it aligns with the input terminal labeled L1.
4. Connect the second three-phase hot wire, typically red, to the input connector so that it aligns with the terminal labeled L2.
5. Connect the third hot wire, typically blue, to the input connector so that it aligns with the terminal labeled L3.

Single-phase AC operation

1. Verify that input AC power to the DC power supply is physically locked out or disconnected.
2. Connect the ground (earth) wire, typically green, to the black input connector so that it aligns with the input terminal labeled with the ground symbol.
3. Connect the AC single-phase hot wire, typically black, to the black input connector so that it aligns with the input terminal labeled L1.
4. Connect the single-phase return wire, typically white, to the input connector so that it aligns with the terminal labeled L2.
5. Connect a jumper wire between terminals L2 and L3 on the input connector using 10–12 AWG wire.

getting started

Connecting

Control connections

All control connections to Firestar t-Series lasers are made through the 15-pin *User I/O* connector on the RF power supply's rear panel. The *User I/O* port receives power commands from SYNRAD's UC-2000 Universal Laser Controller and also serves as the connection point for auxiliary signals between the laser and any parts handling, automation, or monitoring equipment.

⚠ Warning
serious personal injury

Always use shielded cable when connecting your PWM Command signal source to PWM Input / PWM Return inputs. In electrically-noisy environments, long lengths of unshielded wire act like an antenna and may generate enough voltage to trigger uncommanded lasing.

UC-2000 Universal Laser Controller

SYNRAD recommends the use of a UC-2000 Universal Laser Controller to generate pulse width modulated (PWM) Command signals that control the laser's output power. To connect a UC-2000 Controller (available separately), perform the following steps:

1. Remove DC power from the RF power supply.
2. Locate the *Quick Start Plug* in the ship kit.

Note: The *Quick Start Plug* is not included with SA models but may be ordered separately.

3. Connect the *Quick Start Plug* to the *User I/O* connector on the rear of the RF power supply.
4. Attach the BNC connector on the end of the UC-2000's *Power/Control* cable to the BNC connector on the rear of the *Quick Start Plug*.
5. Connect the miniature DC power plug on the UC-2000's *Power/Control* cable to the miniature connector on the cable from the UC-2000's wall plug transformer.
6. Connect the mini-DIN connector on the other end of the UC-2000's *Power/Control* cable to the *Laser* connector on the UC-2000's rear panel.

Note: Firestar t-Series lasers can also be controlled from an alternate user-supplied Command signal source. Refer to *Controlling laser power* in the Technical Reference chapter for control signal descriptions and refer to *User I/O connections*, also in the Technical Reference chapter, for signal specifications and connection details.

Quick Start Plug

Note: The *Quick Start Plug* is not included with SA models but may be ordered separately.

Caution possible equipment damage	Turn off DC power before installing or removing any plug or cable from the *User I/O* connector. Ensure that user connections are made to the appropriate pins and that the appropriate signal levels are applied. Failure to do so may damage the laser.

In order for your Firestar t-Series laser to properly operate, several input signals must be applied to the DB-15 *User I/O* connector before lasing is enabled. Voltage must be applied to Remote Interlock (Pin 3) and Shutter Open Request (Pin 10) inputs before the laser will fire. In applications where Firestar is integrated into an automated system and safety interlocks are required, these input signals must be provided by the customer's control system. The *Quick Start Plug* included in the ship kit has factory-installed shorting jumpers wired into it to enable these inputs. Connect the *Quick Start Plug* to the *User I/O* connector when performing initial start-up and testing of your Firestar laser.

⚠ **Caution** possible personal injury	The *Quick Start Plug* is intended solely for initial start-up and testing of the laser. Because this plug jumpers Remote Interlock and Shutter Open Request signals, the laser will fire immediately on application of a PWM Command signal. Your integrated control system should provide interlock and shutter signals directly to the DB-15 *User I/O* connector only after safe operating conditions are established.

For further information about the *User I/O* connector, see *User I/O connections* in the Technical Reference chapter for *User I/O* pinouts and signal descriptions. See *Integrating Firestar safety features*, also in the Technical Reference chapter, for detailed instructions on integrating Firestar's keyswitch, shutter, and remote interlock functions with automated control systems. Figure 3-8, *Quick Start Plug wiring diagram*, in the Technical Reference chapter shows the *Quick Start Plug* wiring diagram.

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operation 2

Use information in this section to familiarize yourself with Firestar's controls and indicators and to begin operating the laser.

This section contains the following information:

- Controls and indicators – displays and describes exterior controls and indicators on Firestar t-Series lasers.
- Initial start-up – explains how to start your Firestar t-Series laser while verifying proper operation.

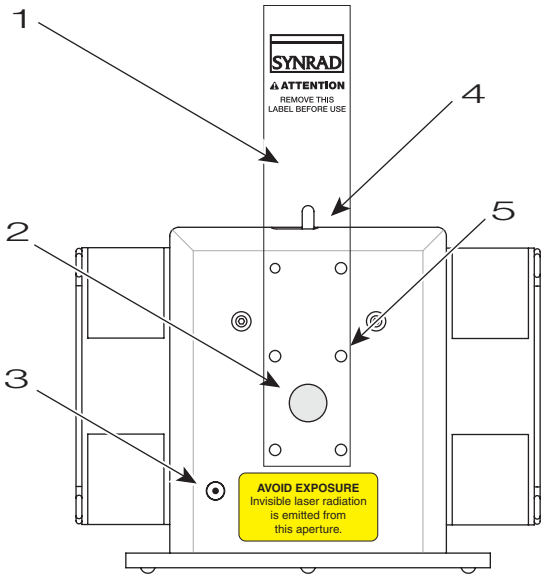
operation

Controls and indicators

The *Controls and indicators* section includes subsections:

- t-Series front panel
- t-Series rear panel
- OEM t-Series side panel (SA models)
- RF-600/RF-800 rear panel
- RF-1000 rear panel

t-Series front panel



(Fan-Cooled t60 Shown)

Figure 2-1 Firestar t-Series front panel controls and indicators

1 Aperture Seal – prevents dust from damaging the output coupler during shipping. Remove the red self-adhesive label before applying power to the laser.

2 Laser Aperture – provides an opening in Firestar's front panel from which the beam exits.

3 *DP POWER* Connector (except SA models) – provides a convenient +5 VDC, 50 mA receptacle to power a visible red diode pointer (available from SYNRAD as an optional accessory).

4 *Shutter Switch* (Keyswitch models only) – activates a mechanical shutter that opens or closes the laser aperture. Closing the shutter also interrupts RF power to the laser. There is a five-second delay imposed from the time the shutter is opened to the time that PWM signals are accepted.

5 Optical Accessories Mounting – provides six threaded holes (8–32 UNC) for mounting optional beam delivery components. Because excessive weight may damage the laser, consult SYNRAD before mounting components not specifically designed as Firestar options. Refer to *Firestar t-Series package outline drawings* in the Technical Reference chapter for mounting hole dimensions.

Controls and indicators

Note: When mounting optical components to t-Series lasers, the 8–32 UNC fasteners must extend no further than 0.19" (4.8 mm) into the laser's faceplate.

t-Series rear panel

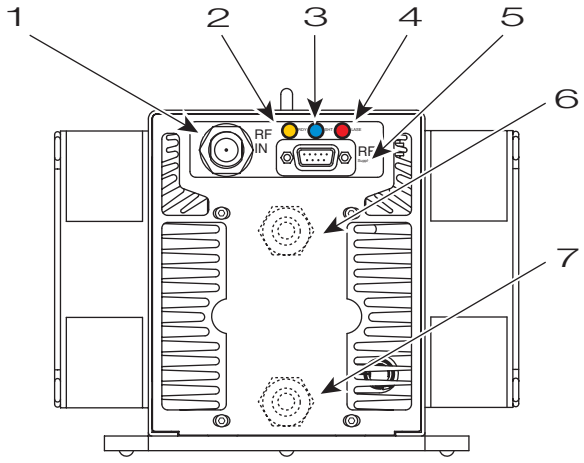


Figure 2-2 Firestar t-Series rear panel controls and indicators

1 *RF IN* Connector – receives RF energy from the RF power supply.

2 *RDY* (Ready) Indicator – illuminates yellow when the laser is enabled, indicating that, after a five-second delay, lasing will begin when a PWM Command signal is applied.

3 *SHT* (Shutter) Indicator – illuminates blue to indicate that the shutter is Open and that lasing may be enabled. The *SHT* indicator is off and lasing is disabled if the shutter is Closed. When switching the shutter from Closed to Open, there is a five-second delay until PWM inputs are recognized.

4 *LASE* Indicator – illuminates red to indicate that the laser is actively lasing. The *LASE* indicator is off when tickle pulses are being generated and illuminates red when PWM Command signal pulses are long enough to produce laser output.

5 *RF Supply* Connector – provides a connection point for the *Interconnect* cable. The *RF Supply* connector receives DC power for cooling fans (fan-cooled versions) and drive signals for *RDY*, *LASE*, and *SHT* LEDs from the RF power supply.

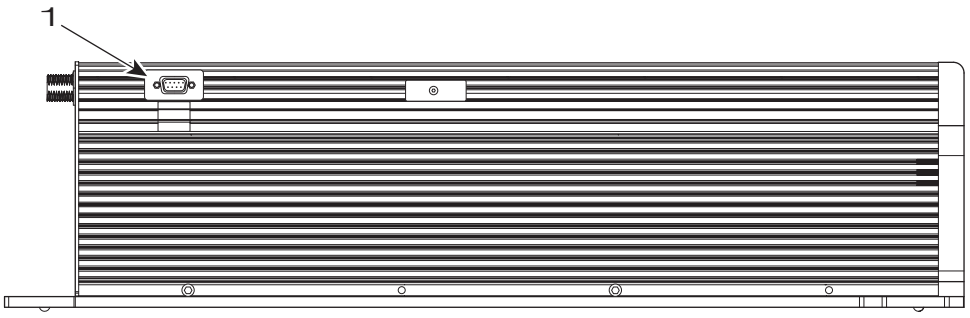
6 *WATER IN* Port (water-cooled models only) – labeled IN, this connection provides the cooling water inlet to Firestar's water-cooling system.

7 *WATER OUT* Port (water-cooled models only) – labeled OUT, this connection provides the cooling water outlet from Firestar's water-cooling system.

operation

Controls and indicators

OEM t-Series side panel (SA models)



(Air-Cooled t60 OEM Shown)

Figure 2-3 OEM t-Series side panel controls and indicators

1 *DB-9* connector – provides a *Shutter Switch* input and auxiliary +5 and +24 VDC outputs. This connector also provides Lase, Shutter, and Ready signals for driving customer-supplied LEDs. See *DB-9 connections* in the Technical Reference chapter for connection details.

Controls and indicators

RF-600/RF-800 rear panel

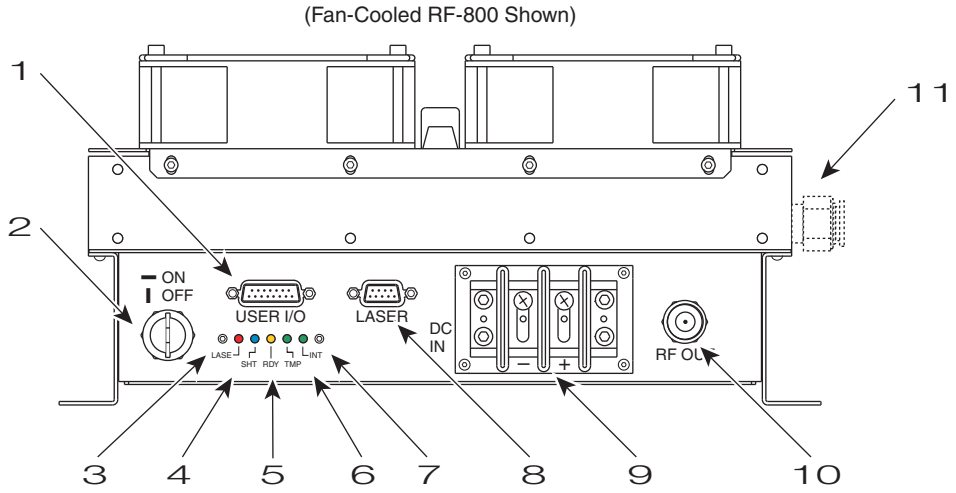


Figure 2-4 RF-600/RF-800 rear panel controls and indicators

1 *USER I/O* Connector – provides a connection point for auxiliary output power as well as input and output signals. Refer to the Technical Reference chapter for pinouts and signal descriptions.

2 *Keyswitch* (keyswitch models only) – enables/disables operation of the laser. The laser is enabled when the *Keyswitch* is turned to the ON position. Turn the *Keyswitch* OFF to disable lasing.

3 *LASE* Indicator – illuminates red to indicate that the laser is actively lasing. The *LASE* indicator is off when tickle pulses are being generated and illuminates red when PWM Command signal pulses are long enough to produce laser output.

4 *SHT* (Shutter) Indicator – illuminates blue to indicate that the shutter is Open and that lasing may be enabled. The *SHT* indicator is off and lasing is disabled if the shutter is Closed. When the shutter is switched Open, there is a five-second delay until PWM inputs are recognized.

5 *RDY* (Ready) Indicator – illuminates yellow when the laser is enabled, indicating that, after a five-second delay, lasing will begin when a PWM Command signal is applied.

6 *TMP* (Temperature) Indicator – illuminates green to indicate that laser temperature is within limits and that lasing may be enabled. The *TMP* indicator is red and lasing is disabled if the laser's temperature rises above safe operating limits.

7 *INT* (Remote Interlock) Indicator – illuminates green to indicate that a remote interlock circuit is closed and that lasing may be enabled. The *INT* indicator is red and lasing is disabled if the interlock input is open.

8 *LASER* Connector – provides a connection point for the *Interconnect* cable. The *LASER* connector sends DC power to the t-Series Laser Head for cooling fans (fan-cooled versions) as well as drive signals for *RDY*, *LASE*, and *SHT* LEDs.

9 *DC IN* Connector – receives DC power from the DC power supply.

10 *RF OUT* Connector – provides RF energy to the t-Series Laser Head.

11 *WATER OUT* and *WATER IN* Ports (water-cooled only) – provides connection points for Firestar's water-cooling system.

operation

Controls and indicators

RF-1000 rear panel

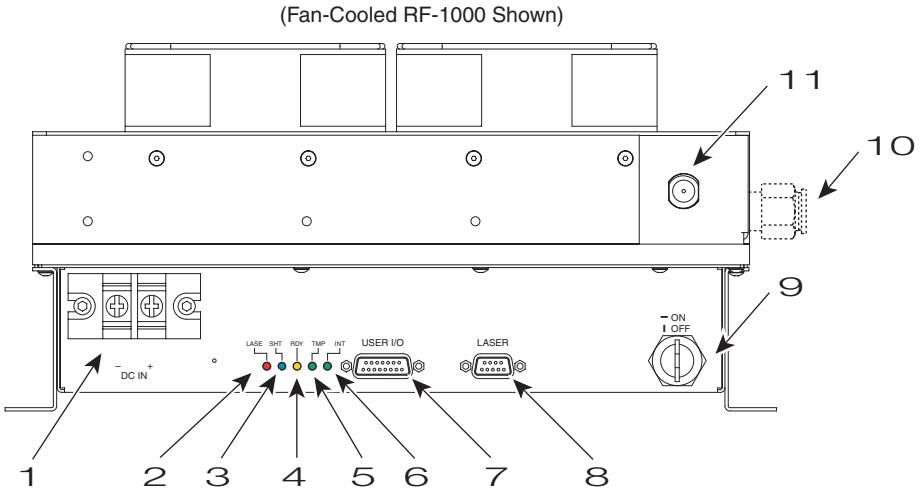


Figure 2-5 RF-1000 rear panel controls and indicators

1 *DC IN* Connector – receives DC power from the DC power supply.

2 *LASE* Indicator – illuminates red to indicate that the laser is actively lasing. The *LASE* indicator is off when tickle pulses are being generated and illuminates red when PWM Command signal pulses are long enough to produce laser output.

3 *SHT* (Shutter) Indicator – illuminates blue to indicate that the shutter is Open and that lasing may be enabled. The *SHT* indicator is off and lasing is disabled if the shutter is Closed. When the shutter is switched Open, there is a five-second delay until PWM inputs are recognized.

4 *RDY* (Ready) Indicator – illuminates yellow when the laser is enabled, indicating that, after a five-second delay, lasing will begin when a PWM Command signal is applied.

5 *TMP* (Temperature) Indicator – illuminates green to indicate that laser temperature is within limits and that lasing may be enabled. The *TMP* indicator is red and lasing is disabled if the laser's temperature rises above safe operating limits.

6 *INT* (Remote Interlock) Indicator – illuminates green to indicate that a remote interlock circuit is closed and that lasing may be enabled. The *INT* indicator is red and lasing is disabled if the interlock input is open.

7 *USER I/O* Connector – provides a connection point for auxiliary output power as well as input and output signals. Refer to the Technical Reference chapter for pinouts and signal descriptions.

8 *LASER* Connector – provides a connection point for the *Interconnect* cable. The *LASER* connector sends DC power to the t-Series Laser Head for cooling fans (fan-cooled versions) as well as drive signals for *RDY*, *LASE*, and *SHT* LEDs.

9 *Keyswitch* (keyswitch models only) – enables/disables operation of the laser. The laser is enabled when the *Keyswitch* is turned to the ON position. Turn the *Keyswitch* OFF to disable lasing.

10 *WATER OUT* and *WATER IN* Ports (water-cooled only) – provides connection points for Firestar's water-cooling system.

11 *RF OUT* Connector – provides RF energy to the t-Series Laser Head.

operation

Initial start-up

The *Initial start-up* section includes subsections:

- With a UC-2000 Controller
- Without a UC-2000 Controller

Note: To ensure optimum performance, t-Series Laser Heads and RF power supplies are tested and shipped as sets. Interchanging components may result in decreased laser performance.

⚠ Warning serious personal injury	On Firestar t-Series OEM lasers, remote interlock (*INT*) faults are not latched. Clearing the fault condition re-enables the *RDY* indicator and the laser will fire after the five-second delay provided that the *SHT* indicator is lit and a PWM Command signal is applied. Because exposure to 10.6 µm CO_2 laser radiation can inflict severe corneal injuries and seriously burn human tissue, the OEM or System Integrator must ensure that appropriate safeguards are in place to prevent unintended lasing.

Caution possible equipment damage	Because of their smaller beam diameter, Firestar lasers have significantly higher power densities than previous SYNRAD lasers. This means that even small amounts of contaminants on the laser's output coupler (or on any beam delivery optic) can absorb enough energy to damage one or more optics in the beam path. Periodically inspect the laser's output coupler and all other beam delivery optics for signs of contaminants, and then carefully clean as required. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

With a UC-2000 Controller

Before your Firestar® laser is put into service for the first time, its functionality should be verified. Follow this procedure to verify the laser system is operating at optimum performance. For this procedure, use the UC-2000 as a stand-alone controller; do not attempt to control the laser or UC-2000 externally.

⚠ Danger serious personal injury	This Class IV laser product emits ***invisible*** infrared laser radiation in the 10.6 µm CO_2 wavelength band. Since direct or diffuse laser radiation can inflict severe corneal injuries, always wear eye protection when in the same area as an exposed laser beam. Do not allow the laser beam to contact a person. This product emits an invisible laser beam that is capable of seriously burning human tissue. Always be aware of the beam's path and always use a beam block while testing.

operation

Initial start-up

Note: When performing the initial start-up sequence, you must first connect the *Quick Start Plug* or you must provide the required Remote Interlock and Shutter Open Request signals to the *User I/O* connector. See *User I/O connections* in the Technical Reference chapter for *User I/O* pinouts and signal descriptions.

Starting auxiliary equipment

1 Ensure that all personnel in the area are wearing protective eyewear.

2 Remove the red self-adhesive aperture seal from the laser faceplate.

3 Place a beam block 24 inches from the laser aperture to prevent the beam from traveling beyond the work area.

4 On water-cooled systems, turn on the chiller (set between 18–22 °C) and verify that it is delivering 0.75–2.0 GPM at less than 60 PSI of pressure. Examine all cooling connections carefully for leaks.

Caution possible equipment damage	Inlet cooling water temperature must always be maintained above the dew point to prevent condensation and water damage to your Firestar laser.

Note: If you have not yet operated your UC-2000 Universal Laser Controller, refer to the *UC-2000 Laser Controller Operator's Manual* for setup and operation instructions before continuing.

5 Set the UC-2000 to *MANUAL* mode, and then set the *PWM Adj Knob* to provide zero percent output (0.0%). The UC-2000's *Lase* indicator should be Off.

6 Verify that the RF power supply's *Keyswitch* (if equipped) is in the OFF position.

7 Turn on the DC power supply.

If the *Quick Start Plug* is installed, the *INT* (Remote Interlock) indicator will illuminate green and the *SHT* (Shutter) indicator will illuminate blue—if the manual *Shutter Switch* is Open. The *TMP* (Temperature) indicator illuminates green if laser temperature is within safe operating limits.

Starting your Firestar t-Series laser

Note: Firestar *RDY* and *SHT* LEDs denote separate control functions. Although the *RDY* lamp may light while the *SHT* LED is Off (*Shutter Switch* Closed or Shutter Open Request signal missing), no power is applied to the RF boards until both *RDY* and *SHT* indicators are illuminated.

1 If the laser has a Diode Pointer installed, remove its aperture dust cover.

2 Place the *Shutter Switch* (if equipped) in the Open position. Blue *SHT* (Shutter) indicators on the RF power supply and the Laser Head will illuminate.

3 Rotate the *Keyswitch* to the ON position. Verify that yellow *RDY* (Ready) indicators on the Laser Head and the RF power supply illuminate.

operation

Initial start-up

Note: Each time an OEM laser is powered up or a keyswitch version is cycled OFF/ON, a five-second delay occurs between the time that *RDY* and/or *SHT* indicators illuminate and Firestar is permitted to lase.

⚠ Warning serious personal injury	Because of phase differences, external tickle pulses may combine with the internally-generated tickle signal causing the *LASE* LED to flicker during the transition from tickle to lasing. Laser output may occur if the *LASE* LED flickers.

Note: For remote operation (keyswitch lasers), it is possible to set the *Keyswitch* to the ON position and use the Remote Reset/Start Request signal (on the *User I/O* connector) as a remote keyswitch, similar to other SYNRAD laser models.

4 Press the UC-2000's *Lase On/Off* button. The *Lase* indicator on the UC-2000 should illuminate.

5 Use the UC-2000's *PWM Adj Knob* to slowly increase power. The laser's *LASE* indicator illuminates red when PWM signal pulses are long enough to produce laser output (typically 3–6 µs at 5 kHz). The spot where the beam hits the beam block increases in brightness, to indicate increased power output.

6 Press the UC-2000's *Lase On/Off* button to stop lasing. *LASE* indicators on the UC-2000, the RF power supply, and the Laser Head should all turn off.

7 Place Firestar's *Shutter Switch* (if equipped) in the Closed position.

8 On water-cooled t-Series lasers, shut off the chiller or otherwise stop coolant flow through the Laser Head and RF power supply.

Caution possible equipment damage	Do not flow coolant through the laser for an extended period of time when the laser is shutdown. This causes condensation to form inside the laser or RF power supply which may result in catastrophic damage to internal optics and electronic circuits.

If your Firestar t-Series laser fails to lase, refer to *Troubleshooting* in the Maintenance/Troubleshooting chapter for troubleshooting information.

operation

Initial start-up

Without a UC-2000 Controller

If you are not using a UC-2000 to control the laser, follow the steps below to verify the laser operation. Although a tickle signal is not required, you will need to provide PWM Command signals to Firestar's *User I/O* connector. Refer to *User I/O connections* in the Technical Reference chapter for connector pinouts and refer to *Controlling laser power* in the Technical Reference chapter for Command signal descriptions.

⚠ **Danger** serious personal injury	This Class IV laser product emits ***invisible*** infrared laser radiation in the 10.6 µm CO_2 wavelength band. Since direct or diffuse laser radiation can inflict severe corneal injuries, always wear eye protection when in the same area as an exposed laser beam. Do not allow the laser beam to contact a person. This product emits an invisible laser beam that is capable of seriously burning human tissue. Always be aware of the beam's path and always use a beam block while testing.

Note: When performing the initial start-up sequence, you must first connect the *Quick Start Plug* or you must provide the required Remote Interlock and Shutter Open Request signals to the *User I/O* connector. See *User I/O connections* in the Technical Reference chapter for *User I/O* pinouts and signal descriptions.

Starting auxiliary equipment

1. Ensure that all personnel in the area are wearing protective eyewear.
2. Remove the red self-adhesive aperture seal from the laser faceplate.
3. Place a beam block 24 inches from the laser aperture to prevent the beam from traveling beyond the work area.
4. On water-cooled systems, turn on the chiller (set between 18–22 °C) and verify it is delivering 0.75–2.0 GPM at less than 60 PSI of pressure. Examine all cooling connections carefully and verify that they do not leak.

Caution possible equipment damage	Inlet cooling water temperature must always be maintained above the dew point to prevent condensation and water damage to your Firestar laser.

5. Connect the output of your PWM Controller to PWM Input (Pin 9) on the RF power supply's *User I/O* connector and connect the ground or return of the Controller to PWM Return (Pin 1).
6. Set your PWM Controller to a frequency of 5 kHz @ +5 VDC and ensure that the Controller's duty cycle is set to zero percent output (0.0%).

7 Verify that the RF power supply's *Keyswitch* (if equipped) is in the OFF position and turn on the DC power supply.

If the *Quick Start Plug* is installed, the *INT* (Remote Interlock) indicator will illuminate green and the *SHT* (Shutter) indicator will illuminate blue—if the manual *Shutter Switch* is Open. The *TMP* (Temperature) indicator illuminates green if laser temperature is within safe operating limits.

Starting your Firestar t-Series laser

Note: Firestar *RDY* and *SHT* LEDs denote separate control functions. Although the *RDY* lamp may light while the *SHT* LED is Off (*Shutter Switch* Closed or Shutter Open Request signal missing), no power is applied to the RF boards until both *RDY* and *SHT* indicators are illuminated.

1 If the laser has a Diode Pointer installed, remove its aperture dust cover.

2 Place the *Shutter Switch* (if equipped) in the Open position. Blue *SHT* (Shutter) indicators on the RF power supply and the Laser Head will illuminate.

3 Rotate the *Keyswitch* to the ON position. Verify that yellow *RDY* (Ready) indicators on the Laser Head and the RF power supply illuminate.

Note: Each time an OEM laser is powered up or a keyswitch version is cycled OFF/ON, a five-second delay occurs between the time that *RDY* and/or *SHT* indicators illuminate and Firestar is permitted to lase.

Note: For remote operation (keyswitch lasers), it is possible to set the *Keyswitch* to the ON position and use the Remote Reset/Start Request signal (on the *User I/O* connector) as a remote keyswitch, similar to other SYNRAD laser models.

⚠ Warning
serious personal injury

Because of phase differences, external tickle pulses may combine with the internally-generated tickle signal causing the *LASE* LED to flicker during the transition from tickle to lasing. Laser output may occur if the *LASE* LED flickers.

4 Using your PWM Controller, slowly increase the duty cycle of the square wave. *LASE* indicators on the RF power supply and the Laser Head illuminate red when PWM pulses are long enough to produce laser output (typically between 3–6 µs at 5 kHz). The spot where the beam hits the beam block increases in brightness, indicating an increased power output.

5 Remove the PWM Command signal from the *User I/O* connector. *LASE* indicators on the RF power supply and the Laser Head should turn off.

6 Place Firestar's *Shutter Switch* (if equipped) in the Closed position.

operation

Initial start-up

Caution possible equipment damage	Do not flow coolant through the laser for an extended period of time when the laser is shutdown. This causes condensation to form inside the laser or RF power supply which may result in catastrophic damage to internal optics and electronic circuits.

7 On water-cooled t-Series lasers, shut off the chiller or otherwise stop coolant flow through the Laser Head and RF power supply.

If your Firestar t-Series laser fails to lase, refer to *Troubleshooting* in the Maintenance/Troubleshooting chapter for troubleshooting information.

technical reference

3

Use information in this section as a technical reference for your Firestar t-Series laser.

This section contains the following information:

- Technical overview – briefly describes Firestar's technology and basic optical setup.
- Controlling laser power – explains various aspects of Firestar control signals.
- User I/O (Input/Output) connections – describes signals and specifications for the RF power supply's User I/O connector.
- DB-9 connections (SA models only) – describes signals and specifications for the SA model's side-mounted DB-9 connector.
- Integrating Firestar safety features – describes how to integrate Firestar t-Series safety features into your automated control system.
- t60 general specifications – provides specifications for both Keyswitch and OEM Firestar t60 lasers.
- t80 general specifications – provides specifications for both Keyswitch and OEM Firestar t80 lasers.
- t100 general specifications – provides specifications for both Keyswitch and OEM Firestar t100 lasers.
- Firestar t-Series package outline drawings – illustrates laser package and mounting dimensions for Keyswitch and OEM t60/t80/t100 Laser Heads.
- RF-600/RF-800 package outline drawings – illustrates RF power supply package and mounting dimensions for Keyswitch and OEM RF-600/RF-800's.
- RF-1000 package outline drawings – illustrates RF power supply package and mounting dimensions for Keyswitch and OEM RF-1000's.
- t-Series cable outline drawings – illustrates RF and Interconnect cable package dimensions.
- Packaging instructions – describes how to package t-Series Laser Heads and RF power supplies for shipment.

technical reference

Technical overview

The *Technical overview* section includes subsections:

- t-Series Laser Head
- RF power supply
- Optical setup

t-Series Laser Head

Laser tube

Firestar® t-Series lasers were developed using new technology patented by SYNRAD, Inc. Firestar's patented "t" technology, based on a combination of free-space and waveguide resonator designs, enables SYNRAD to economically produce a symmetrical laser beam from a small but powerful laser capable of operating for many years with virtually no maintenance. Firestar's unique extruded aluminum envelope offers excellent heat transfer, long gas life, and low operating costs in contrast to other laser tube technologies. Besides being the vessel that maintains the lasing environment, the aluminum tube is also the structural platform that integrates the laser's optical, electrical, and cooling components.

Optical resonator

The optical resonator, in conjunction with the electrodes and the gas mixture, generates the laser beam. Firestar t-Series optical resonators are comprised of three optical elements: a front mirror, a rear mirror, and an output window. These optical elements are fastened to the tube's exterior and are exposed to its interior through holes in the end caps. O-rings are sandwiched between optical elements and the end cap to form a gas seal and to provide a flexible cushion that allows the slight movement necessary for alignment. All optical elements are aligned and locked into place by factory technicians before the laser is shipped.

Caution
possible equipment damage

Because of their smaller beam diameter, Firestar lasers have significantly higher power densities than previous SYNRAD lasers. This means that even small amounts of contaminants on the laser's output coupler (or on any beam delivery optic) can absorb enough energy to damage one or more optics in the beam path. Periodically inspect the laser's output coupler and all other beam delivery optics for signs of contaminants, and then carefully clean as required. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

The output beam, roughly circular as it exits the resonator, transitions to a Gaussian-like mode in five to ten Raleigh ranges (1.6–3.3 m). The internal structure and optics of the resonator combine to produce a Gaussian-like mode quality (M^2 factor) $\leq$ 1.2. As shown in Figure 3-1, beam waist diameter is 2.2 mm at the output aperture and full angle divergence due to diffraction is less than 7 milliradians (a 7 mrad full angle divergence means that beam diameter increases 7 mm over every one meter distance traveled).

technical reference

Technical overview

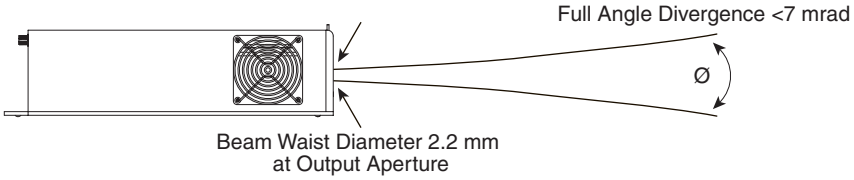


Figure 3-1 t-Series beam characteristics

RF power supply

The RF power supply converts DC input power into a radio frequency (RF) signal using a crystal-controlled oscillator. The 81.36 MHz RF output from the oscillator is then amplified to obtain the RF power required to drive the laser. From the amplifier, RF power is routed through a matched RF power cable to the electrode structure in the laser where it excites carbon dioxide (CO_2) gas in the tube to produce lasing.

Control circuit

Control circuitry built into the RF power supply interrupts laser operation if any critical parameter is violated. Switches and sensors monitor various conditions and parameters that, if exceeded, pose a risk of potential damage to the laser or the RF power supply. Additionally, laser operation is interrupted in response to the following conditions: (1) the manual *Shutter Switch* is closed; (2) the Shutter Open Request signal is missing; (3) an over temperature condition occurs; (4) the Remote Reset/Start Request signal is enabled; or (5) the Remote Interlock signal is missing.

Optical setup

After selecting a laser for a CO_2 laser processing system, the two most important elements to consider are: (1) beam delivery optics to transmit the beam to the work area; and (2) focusing optics to focus the beam onto the part or material to be processed. Each element is crucial in the development of a laser-based material processing system and each element should be approached with the same careful attention to detail.

Delivery optics

Divergence, or expansion, of the laser beam is important for materials processing since a larger beam entering the focusing optic produces a smaller focused spot. Because the laser beam diverges 7 mm over each meter of distance traveled, the laser should be mounted a distance of 40–60 inches (1.0–1.5 m) away from the work area and no closer than 30 inches (0.75 m) for optimum performance. Right angle turning mirrors are often used in conjunction with the laser mounting position to obtain this distance. Figure 3-2 shows how right angle turning mirrors in a "flying optics" setup create this longer beam path.

Note: Optical components in the beam path must always be aligned to the actual beam path, not the laser faceplate. Because of slight variations in laser construction, the beam path may not always be centered in, or perpendicular to, the aperture in the faceplate.

Expander/collimators are optical devices that reduce laser divergence while at the same time increasing beam diameter by a selectable magnification factor. Adding an expander/collimator to the "flying optics" setup shown above would substantially reduce beam divergence and any variance in beam diameter caused by the changing optical path length. In fixed-length delivery systems where the laser is positioned only one meter away from the focusing optic and a small spot size is required, an expander/collimator is again the best solution to provide the required beam expansion before reaching the focusing optic.

technical reference

Technical overview

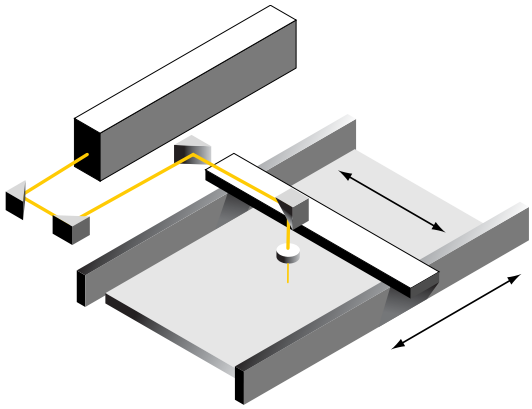


Figure 3-2 "Flying optics" beam path

Focusing optics

When selecting a focusing optic, the primary consideration should be material thickness and any vertical tolerances that occur during final part positioning rather than making a selection based only on minimum spot size. The chosen focal length should create the smallest possible focused spot while providing the depth of field required for the material to be processed.

Caution
possible equipment damage

Small amounts of contaminants on the laser's output window (or on any optics in the beam path) can absorb enough energy to damage the optic. Inspect all beam delivery optics periodically for signs of contaminants and carefully clean as required. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

Optics are fragile and must be handled carefully, preferably by the mounting ring only. Cleanliness is another important issue affecting performance; a dirty or scratched lens will under perform and exhibit a vastly shortened lifetime. When the application requires air (instead of nitrogen) as an assist gas, use only breathing quality air available in cylinders from a welding supply company. Compressed shop air contains minute particles of oil and other contaminants that will damage optical surfaces. If compressed shop air is the only choice available, it must be filtered to the specifications shown in Table 3-1.

Table 3-1 Assist gas purity specifications

Purge Gas	Specification	
Nitrogen	High Purity Grade	99.9500% purity or better
Air	Breathing Grade	99.9996% purity or better
Air	Compressed	99.9950% purity or better, water-free; oil filtered to 5 mg/m^3 or better; particulate filtered to < 1.0 micron.

technical reference

Controlling laser power

The *Controlling laser power* section includes subsections:

- Control signals
- Operating modes

Control signals

Much of the information provided in this section describes the use of a SYNRAD UC-2000 Universal Laser Controller to provide PWM Command signals to the t-Series laser. If using an alternate method of laser control, thoroughly review this section, *Controlling laser power*, as well as the following section, *User I/O connections*, for an understanding of the signal requirements necessary to control Firestar lasers. For more information about the UC-2000, please consult the *UC-2000 Laser Controller Operator's Manual*.

Tickle pulse

Firestar lasers incorporate a built-in tickle generator, freeing customers from the need to supply tickle pulses between lasing commands. In cases where a 5 kHz, 1 microsecond (µs) tickle pulse is still sent to the laser via a UC-2000 or other PWM controller, it is ignored until pulse width exceeds approximately 4 µs, at which point lasing occurs.

⚠ **Warning** serious personal injury	Because of phase differences, external tickle pulses may combine with the internally-generated tickle signal causing the *LASE* LED to flicker during the transition from tickle to lasing. Laser output may occur if the *LASE* LED flickers.

Tickle pulses pre-ionize the laser gas to just below the lasing threshold so that a further increase in pulse width adds enough energy to the plasma to cause laser emission. Tickle pulses cause the laser to respond predictably and almost instantaneously to PWM Command signals, even when there is considerable delay (laser off time) between applied Command signals.

Pulse Width Modulation (PWM)

Pulse Width Modulation, or PWM, controls laser power by varying the duty cycle of Firestar's RF amplifiers, which in turn control the time-averaged RF power applied to the laser. Typically, laser output follows the PWM input with a rise and fall time constant of ~75 µs; however, the laser cannot precisely follow PWM input signals if the "On" pulse is less than 75 µs in duration. At a constant 50% duty cycle, t-Series lasers typically reach 90–100% of full optical output when operated at a frequency of 5 kHz. The percentage of optical output increases as duty cycle increases (at a constant PWM frequency) or as PWM frequency decreases (at a constant duty cycle). Figure 3-3 on the following page shows representative t-Series optical output waveforms at two different duty cycles with the same PWM frequency.

Controlling laser power

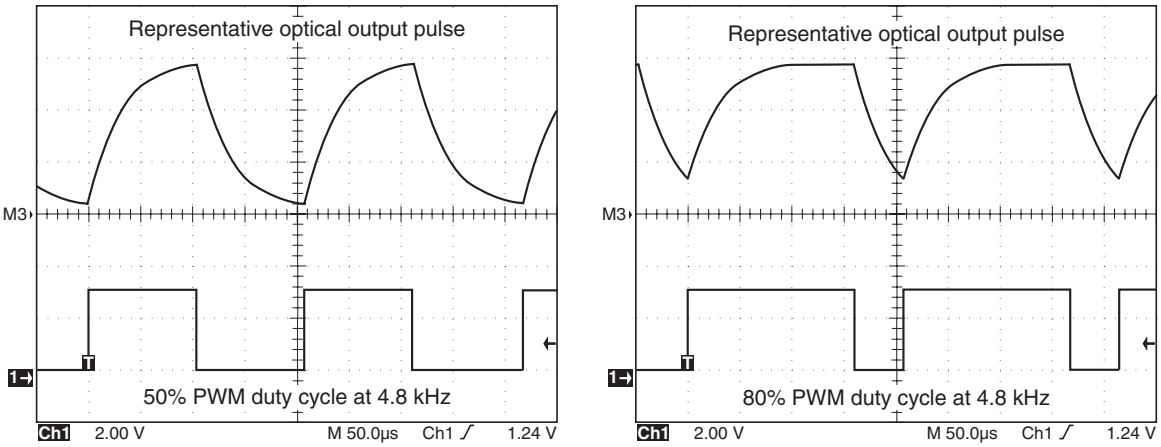

Representative optical output pulse
M3
50% PWM duty cycle at 4.8 kHz
Ch1 2.00 V M 50.0µs Ch1 1.24 V
Representative optical output pulse
M3
80% PWM duty cycle at 4.8 kHz
Ch1 2.00 V M 50.0µs Ch1 1.24 V

Figure 3-3 Representative Firestar t-Series waveforms

Firestar t-Series lasers are designed to operate at Command signal base frequencies up to 25 kHz; however, the choice of PWM frequency depends on the user's specific application. In the majority of laser applications, the UC-2000's default Command signal frequency of 5 kHz has proven to work well. When considering Command frequencies at 5 kHz or below, please review *Marking/engraving operation* later in this section. For high-speed motion applications that cannot tolerate any ripple in the optical beam response but still need adjustable power levels, we recommend the use of higher PWM frequencies, up to 25 kHz maximum. At 25 kHz, the laser's optical beam response no longer follows the Command input and is very nearly a DC value with just a small amount of ripple present.

Command signal

⚠ Warning
serious personal injury

Always use shielded cable when connecting your PWM Command signal source to PWM Input / PWM Return inputs. In electrically-noisy environments, long lengths of unshielded wire act like an antenna and may generate enough voltage to trigger uncommanded lasing.

The modulated Command signal applied between Pin 9, PWM Input, and Pin 1, PWM Return, of the *User I/O* connector on the RF power supply has three basic parameters: signal amplitude, base frequency, and PWM duty cycle. By changing these parameters, you can command the beam to perform a variety of marking, cutting, welding, or drilling operations.

The first Command signal parameter, signal amplitude, is either logic low—corresponding to laser beam off, or logic high—corresponding to beam on. The laser off voltage, typically 0 V, can range from 0.0 V to +0.8 VDC while the laser on voltage, typically 5 V, can range from +3.5 V to +6.7 VDC.

Base frequency, the second parameter, is the repetition rate of the PWM input signal. The standard base frequency is 5 kHz, which has a period of 200 µs. Maximum PWM frequency is 25 kHz.

Controlling laser power

The third Command signal parameter, PWM duty cycle, is the percentage of the period that the Command signal is high. If the Command signal's amplitude (at 5 kHz) is high for 100 µs and low for 100 µs, it has a 50% duty cycle; if the amplitude is high for 190 µs and low for 10 µs, it has a 95% duty cycle. Figure 3-4 illustrates PWM Command signal parameters while Table 3-2 lists PWM signal specifications.

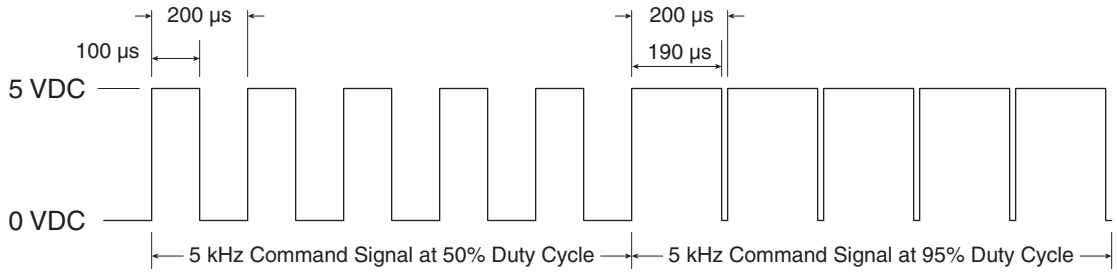


Figure 3-4 PWM Command signal waveform

Firestar's *User I/O* PWM input consists of a high-speed optoisolator LED and a forward voltage drop (Vf) of 1.5 VDC. The PWM input frequency can range from DC (0 Hz) to 25 kHz. Table 3-2 provides minimum, maximum, and nominal PWM signal specifications.

Table 3-2 PWM Command signal levels

Laser State	Minimum	Nominal	Maximum
Laser Off	0.0 VDC	0.0 VDC	+0.8 VDC
Laser On	+3.5 VDC (3 mA)	+5.0 VDC (6 mA)	+6.7 VDC (10 mA), continuous
Frequency Range	0 Hz (DC)	5 kHz	25 kHz
Duty Cycle	0%	— —	100%

Operating modes

External control

In addition to controlling the Firestar laser using a UC-2000 Controller, control of Firestar externally, without a UC-2000, is also possible. The two primary elements of laser control are gating, the ability to turn the laser on and off at the appropriate times, and power, the ability to control the laser's output energy. Both gating and power can be handled by a device such as a personal computer, Programmable Logic Controller (PLC), or function generator capable of sending PWM pulses at the proper time (gating) and with the proper duty cycle (power).

Analog voltage or current control

Although Firestar t-Series lasers cannot be controlled directly by analog voltage or current signals, this type of control is possible when using the UC-2000 Controller. The Controller is connected normally to the laser and analog voltage or current signals sent to the UC-2000's *ANV/C* connector then control both laser gating and power.

technical reference

Controlling laser power

To generate the correct analog voltage from a computer or PLC, a Digital-to-Analog (D/A or DAC) card capable of generating 0 V (laser off) to 10 V (maximum laser power) must be installed. To generate the proper analog current, install a D/A card that can generate 4 mA (laser off) to 20 mA (maximum power). Software able to control your analog output card is required for either configuration.

Continuous wave (CW)

In some applications, such as high speed marking or cutting, the time constant of the laser and the PWM modulation causes a series of dots that may be visible on the marking surface instead of a "clean" line. Operating the laser in CW mode will prevent this behavior from occurring.

To operate the laser in CW mode, apply a constant +5 VDC signal to Pin 9, PWM Input, and Pin 1, PWM Return, on the *User I/O* connector. This constant voltage source forces the internal switching electronics to remain on, providing continuous and uninterrupted laser output power. During CW operation, output power cannot be changed. To adjust output power, refer back to the *Pulse Width Modulation (PWM)* section for information regarding high frequency operation

Note: SYNRAD lasers are designed for maximum performance using a 95% duty cycle. Increasing the maximum PWM percentage beyond 95% greatly increases the laser's heat load with little or no corresponding increase in laser output power. Continuous operation at 99% duty cycle may lead to thermal instability and optical degradation.

Gated operation

In many marking and cutting applications, the laser is required to pulse, or gate, on and off in synchronization with an external control signal (typically from a computer or function generator operating in the range from DC to 1 kHz). To pulse or gate the laser, connect a signal providing +5.0 VDC pulses to the *Gate* connector on the rear panel of the UC-2000.

Users who intend to use a gating signal should set the UC-2000's gate input logic to internal Pull-Down (normally off) mode. This prevents the beam from being enabled unless a high level (+3.5 V to +5.0 VDC) signal is applied to the *Gate* input connector. In the pull-down (normally off) mode an asserted logic low signal, short circuit to ground, or an open or disconnected *Gate* input locks the beam off.

⚠ Warning
serious personal injury

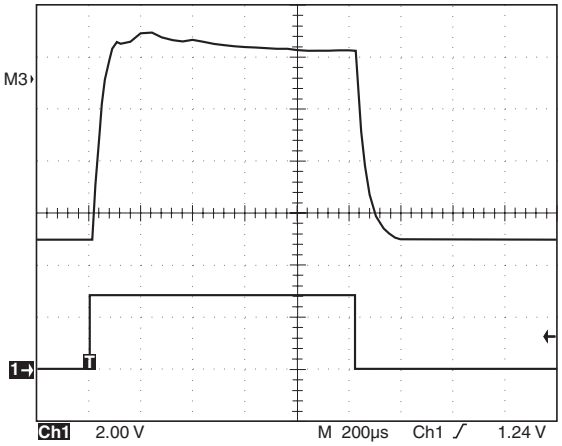
The UC-2000's default gate logic is factory set to internal Pull-Up (normally on) mode so that an open (disconnected) *Gate* input causes the laser to turn on. This functionality allows the user to easily test and verify laser operation prior to integration.

In an integrated system, you should configure the UC-2000's gate input logic to internal Pull-Down (normally off) mode. This prevents the beam from being enabled unless a high level (+3.5 V to +5.0 VDC) signal is applied to the *Gate* input connector. In the Pull-Down (normally off) mode an asserted logic low signal, short circuit to ground, or an open or disconnected *Gate* input locks the beam off.

Many CO_2 lasers operating in applications requiring short gating pulses at repetition rates below 500 Hz will exhibit some leading edge overshoot regardless of the PWM frequency. This occurs because a cooler lasing medium (the CO_2 gas) is more efficient than a hotter one. The overshoot effect is more pronounced at lower gating frequencies since the gas has a longer time to cool down between Command signal pulses.

Controlling laser power

SYNRAD's Firestar t-Series lasers produce an optical output pulse that is almost exactly square (see Figure 3-5), meaning that there is no leading edge overshoot and virtually no power variation across the actual pulse. The square output pulse of the t-Series laser coupled with its shorter rise times (~75 µs) means that material processing is more efficient since a greater amount of laser energy is absorbed, which is especially desirable when working with high threshold materials.



Optical output pulse (10% duty cycle at 100 Hz)

Figure 3-5 t-Series optical output pulse

Marking/engraving operation

When the delay between the end of one PWM Command signal pulse and the beginning of the next PWM pulse exceeds 200 microseconds (less than or equal to 5 kHz), Firestar's on-board tickle generator sends a tickle pulse to maintain plasma ionization in the tube. Because the on-board tickle generator can not anticipate when the next PWM Command pulse will arrive, the tickle pulse (which typically lasts for 2–6 µs depending on the laser) can effectively merge with a PWM signal that follows closely afterwards. When the PWM pulse that follows is short, causing the tickle pulse to become a significant fraction of the PWM pulse duration, then the tickle pulse effectively substantially increases the length of the PWM pulse it has merged with. For subtle marking applications on sensitive, low threshold materials this lengthened PWM pulse may affect mark quality.

While this situation can occur when using PWM Command signal frequencies of 5 kHz and less, it is important to note that it isn't the Command signal frequency itself that is the determining factor but rather this behavior happens only when the off time between PWM pulses exceeds 200 microseconds.

technical reference

User I/O connections

The *User I/O connections* section includes subsections:

- User I/O connection summary
- Input/output signals
- Sample I/O circuits

User I/O connection summary

Table 3-3 below provides a quick reference summary for Firestar t-Series *User I/O* connections.

Table 3-3 User I/O pin descriptions

Pin	Function	Description
1	PWM Return	Use this input pin to provide the return side of the PWM Command signal.
2	Remote Reset/Start Request	Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to reset or remote keyswitch the laser. The laser remains disabled while voltage is applied. Removing voltage from the Remote Reset/Start Request pin causes the laser's *RDY* indicator to illuminate and begins a five-second countdown after which lasing is enabled.
3	Remote Interlock	Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not use a remote interlock, this pin must be connected to a voltage source in the range of ±5–24 VDC. Refer to Figure 3-8 for a diagram showing how the Remote Interlock input is factory-jumpered.
4	+ 5 VDC Auxiliary Power	This connection provides +5 VDC for driving external inputs or outputs. The +5 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.
5	+ 24 VDC Auxiliary Power	This connection provides +24 VDC for driving external inputs or outputs. The +24 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.
6	Laser Active	This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is actively lasing (*LASE* indicator illuminated red). This output is open (high impedance) when no beam is being emitted (*LASE* indicator Off).
7	Over Temperature	This bi-directional switched output is internally connected to Pin 13, Output Common, when laser or RF power supply temperature is above safe operating limits (*TMP* indicator illuminated red). The output is open (high impedance) when laser and RF power supply temperature is within operating limits (*TMP* indicator green).

User I/O connections

Pin	Function	Description
8	Laser Ready	This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is enabled (*RDY* indicator illuminated yellow), indicating that lasing will occur when a PWM Command signal is applied to Pin 9 and Pin 1. When this output is initially switch closed, there is a five-second delay during which lasing is inhibited. This output is open (high impedance) when the laser is disabled (*RDY* indicator Off).
9	PWM Input	Connect your PWM Command signal (+5 VDC, 5 kHz nominal, 25 kHz max, pulse width modulated) to this input pin to control laser output power. Refer back to *Controlling laser power* for further information on laser control signals.
10	Shutter Open Request	Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not supply a Shutter Open Request signal, this pin must be connected to a voltage source in the range of ±5–24 VDC. Refer to Figure 3-8 for a diagram showing how the Shutter Open Request input is factory-jumpered. When a voltage is initially applied to this input, there is a five-second delay during which lasing is inhibited.
11	Input Common	Use this input pin to connect return lines for Remote Interlock, Shutter Open Request, and Remote Reset/Start Request lines.
12	Auxiliary DC Power Ground	This connection provides a ground (earth) connection for +5 and +24 VDC auxiliary power outputs. This pin is the only *User I/O* pin that is connected to chassis ground. Do not use this pin for grounding if DC power to external I/O circuits is supplied from an external customer-supplied DC power source.
13	Output Common	Use this pin to complete the return path for output connections (Pin 6, 7, 8, 14, or 15). The Output Common line is protected by a 0.25 A self-resetting fuse.
14	Shutter Open	This bi-directional switched output is internally connected to Pin 13, Output Common, when the *Shutter Switch* is Open and a Shutter Open Request signal is present (*SHT* indicator illuminated blue), indicating that lasing may be enabled if other operating conditions are met. When this output is initially switched closed, there is a five-second delay during which lasing is inhibited. This output is open (high impedance) when the laser is disabled (*SHT* indicator Off).
15	Interlock Open	This bi-directional switched output is internally connected to Pin 13, Output Common, when remote interlock circuitry is open (*INT* indicator illuminated red), indicating that lasing is disabled. The output is open (high impedance) when lasing is enabled (*INT* indicator green).

technical reference

User I/O connections

Input/output signals

Firestar's input/output signals are divided into three categories: auxiliary DC power, input signals, and output signals. Signals in each category are fully described in the section below. Figure 3-6 illustrates the pin arrangement of the *User I/O* (15 pin female D-type subminiature) connector on the RF power supply's rear panel.

Note: See *DB-9 connections* later in this section for signal descriptions and pinouts of the SA model's side-mounted DB-9 connector.

Caution
possible equipment damage

Turn off DC power before installing or removing any plug or cable from the *User I/O* connector. Ensure that user connections are made to the appropriate pins and that the appropriate signal levels are applied. Failure to do so may damage the laser.

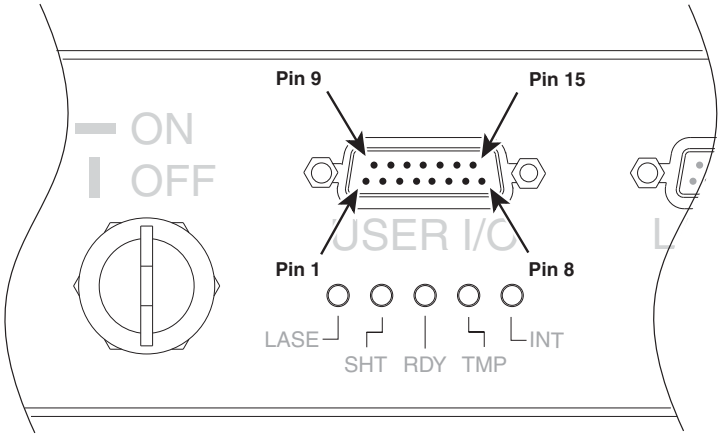


Figure 3-6 User I/O connector pinouts

User I/O connections

Auxiliary DC power

Firestar's *User I/O* connector provides auxiliary DC power for driving external inputs or outputs connected to the *User I/O* port. Pin 4, +5 VDC Auxiliary Power, and Pin 5, +24 VDC Auxiliary Power, are protected by self-resetting fuses rated at 0.5 A. Pin 12, Auxiliary DC Power Ground, is connected to chassis ground while all other *User I/O* pins are floating with respect to chassis ground. Figure 3-7 illustrates Firestar's internal DC supply wiring.

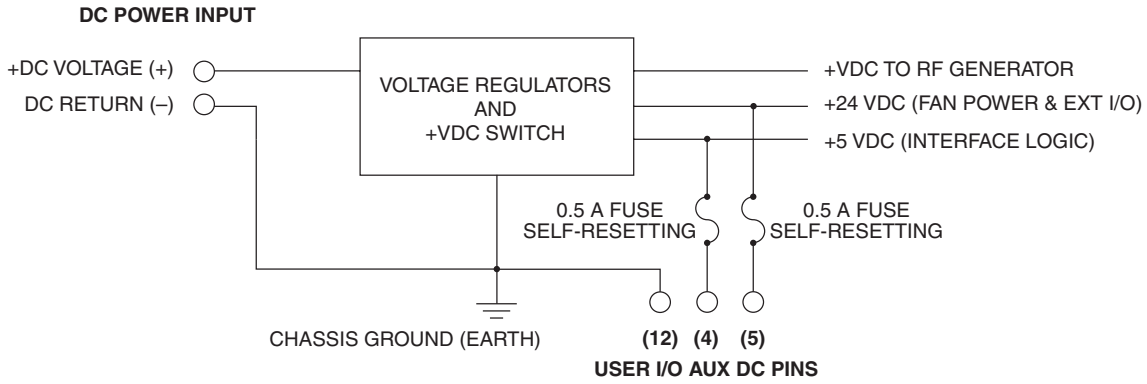


Figure 3-7 Auxiliary power supply wiring

Pin 4 + 5 VDC Auxiliary Power

This connection provides +5 VDC for driving external inputs or outputs. The +5 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.

Pin 5 + 24 VDC Auxiliary Power

This connection provides +24 VDC for driving external inputs or outputs. The +24 VDC Auxiliary Power output can source up to 0.5 A and is protected by a 0.5 A self-resetting fuse. The return (ground) path must be through Pin 12, Auxiliary DC Power Ground.

Pin 12 Auxiliary DC Power Ground

This connection provides a ground (earth) connection for +5 and +24 VDC auxiliary power outputs. This pin is the only *User I/O* pin that is connected to the laser's chassis ground. Do not use this pin for grounding if I/O circuits are powered from an external customer-supplied DC power source.

technical reference

User I/O connections

Input signals

A total of four user inputs allow control of Firestar lasers. Remote Interlock, Shutter Open Request, and Remote Reset/Start Request inputs are optoisolated and bi-directional, allowing for positive or negative polarity signal inputs. These three signals also share a common return connection, Input Common, which is separate from chassis ground to completely isolate control signals for optimal EMI performance. The fourth input, PWM Input, is optoisolated and has a separate return, PWM Return, to fully isolate PWM signals from the other three user inputs. Note that throughout this manual, input voltage levels are specified with respect to their corresponding return line.

Pin 1 PWM Return

Connect the return side of your PWM Command signal to this pin. Refer to Table 3-4 for input circuit specifications.

Pin 2 Remote Reset/Start Request

Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to disable the laser. The laser remains disabled while voltage is applied to this pin. Removing voltage from the Remote Reset/Start Request pin causes the laser's *RDY* indicator to illuminate and begins a five-second countdown after which lasing is enabled. Because all DC power is removed from the laser's RF board when this input is active, no lasing can occur until voltage is removed from Pin 2. Refer to Table 3-4 for input circuit specifications.

For *Keyswitch*-equipped lasers in automated systems, the Remote Reset/Start Request input can operate as a remote keyswitch. To use this "remote keyswitch" functionality, first place the *Keyswitch* in the ON position. Then after each DC power-up cycle (or to reset a fault condition), apply a momentary voltage pulse in the range of ±5–24 VDC to Pin 2. This reset action initiates a five-second delay after which lasing is enabled.

Pin 3 Remote Interlock

Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not use a remote interlock, this pin must be connected to a voltage source in the range of ±5–24 VDC. Refer to Figure 3-8 for a diagram showing how the Remote Interlock input is factory-jumpered. Because all DC power is removed from the laser's RF board when this input is inactive, no lasing can occur until voltage is applied to Pin 3. Refer to Table 3-4 for input circuit specifications.

After voltage is removed and then re-applied to the Remote Interlock input on keyswitch-equipped lasers, the *Keyswitch* or the Remote Reset/Start Request input must be toggled to restart the laser. This action initiates a five-second delay during which lasing is inhibited.

On OEM lasers, the Remote Interlock input is not latched. Re-applying a signal to Pin 3 enables the *RDY* indicator and lasing is possible after the five-second delay, provided that the Shutter Open Request signal is also present (SHT indicator illuminated).

Pin 9 PWM Input

Connect your PWM Command signal (+5 VDC, 5 kHz nominal, 25 kHz max) to Pin 9. This pulse width modulated Command signal controls laser output so that a duty cycle of 50% corresponds to a laser output of approximately one-half rated output power and a duty cycle of 95% corresponds to approximately full output power. Refer to *Controlling laser power* in this chapter for further information on laser control signals. Connect the PWM signal source return to Pin 1, PWM Return. See Table 3-4 for input circuit specifications.

Pin 10 Shutter Open Request

Apply a positive or negative voltage (±5–24 VDC) with respect to Pin 11, Input Common, to enable lasing. If your system does not supply a Shutter Open Request signal, this pin must be connected to a voltage source in the range of ±5–24 VDC. Refer to Figure 3-8 for a diagram showing how the Shutter Open Request input is factory-jumpered. When a voltage is initially applied to this input, there is a five-second delay during which lasing is inhibited. Because all DC power is removed from the laser's RF board when this input is inactive, no lasing can occur until voltage is applied to Pin 10. See Table 3-4 for input circuit specifications.

To enable *Keyswitch*-equipped lasers, you must apply a voltage (in the range of ±5–24 VDC) to the Shutter Open Request input and move the manual *Shutter Switch* to the Open position. Lasing is inhibited when voltage is removed from Pin 10 or the *Shutter Switch* is Closed.

Note: To ensure optimum laser performance, there is a five-second delay imposed from the time a Shutter Open Request occurs to the time that PWM Command signals are accepted.

Pin 11 Input Common

Use this pin to connect return lines for Remote Interlock, Shutter Open Request, and Remote Reset/Start Request lines. Refer to Table 3-4 for input circuit specifications.

Figure 3-8 illustrates how Remote Interlock and Shutter Open Request inputs are factory-jumpered on the *Quick Start Plug* to enable lasing for initial testing and troubleshooting purposes.

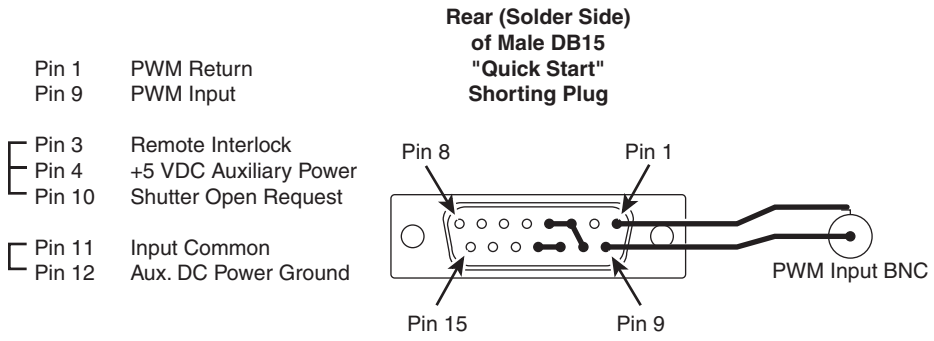


Figure 3-8 Quick Start Plug wiring diagram

Figure 3-9 on the following page illustrates the input circuit's equivalent internal schematic while Table 3-4 provides Firestar t-Series input circuit specifications.

User I/O connections

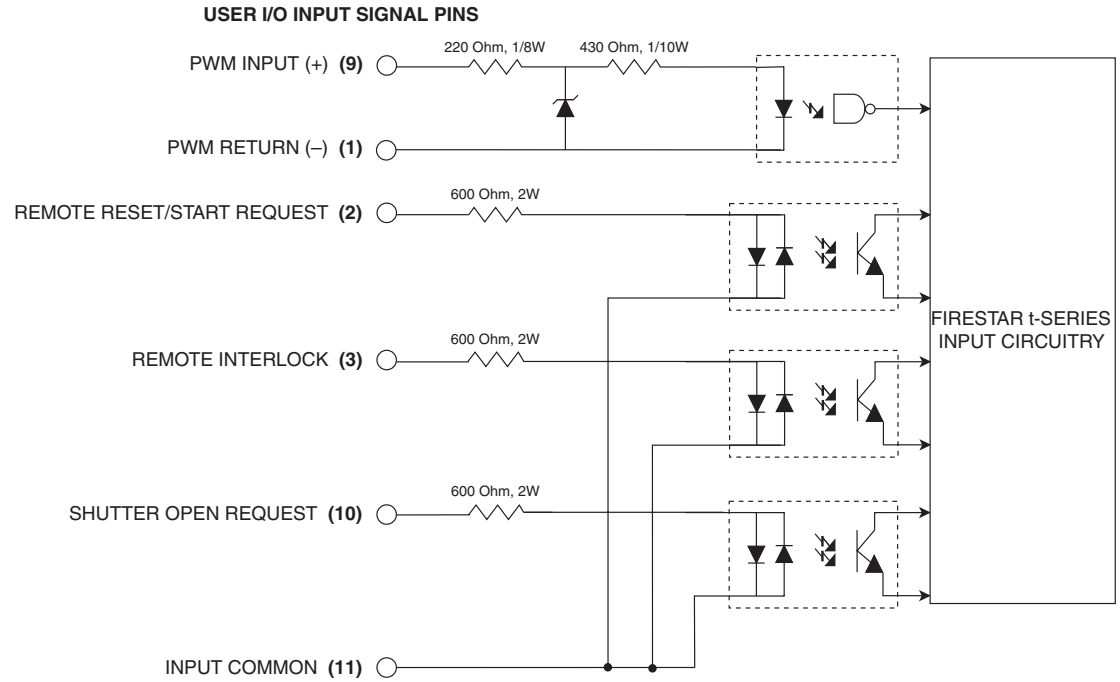


Figure 3-9 Input equivalent schematic

Table 3-4 Input circuit specifications

Input Signal Name	Input Device Type and Specifications
PWM Input	High-speed optoisolator LED, forward voltage drop (Vf) 1.5 VDC Off state Vmax +0.8 VDC On state Vmin +3.5 VDC @ 3 mA On state (continuous) Vmax +6.7 VDC @ 10 mA Frequency, max. 25 kHz
Remote Reset/Start Request Remote Interlock Shutter Open Request	Bi-directional optoisolator LED, forward voltage drop (Vf) 1.15 VDC Off state Vmax < 1.0 VDC On state Vmin ±5.0 VDC @ 7 mA On state (continuous) Vmax ±24.0 VDC @ 40 mA

Note: The Remote Reset/Start Request input must not be sent until Firestar's +5 VDC power supply has stabilized (approximately 200 ms after DC power-up).

User I/O connections

Output signals

Firestar's five user outputs correspond to the status functions described below. Outputs are optoisolated, bi-directional analog switches that allow for high-side or low-side switching. The shared connection, Output Common, is separate from the laser's chassis ground to allow high-side or low-side switching and to isolate control signals for optimum EMI performance.

Firestar's optically-isolated outputs are useful for sending laser status to a Programmable Logic Controller (PLC) or computerized control system. Each of the five outputs can source 50 mA at ±24 VDC maximum for a total load of 250 mA. For controlling larger loads, use these outputs to drive control relays.

Note: Laser Ready and Shutter Open outputs indicate separate functions. The Laser Ready output (*RDY* LED On) may close while the Shutter Open output is open (*SHT* LED Off), but RF boards are disabled until Laser Ready and Shutter Open outputs are closed (*RDY* and *SHT* LEDs On).

Pin 6 Laser Active

This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is actively lasing (*LASE* indicator red). This output is open (high impedance) when no beam is being emitted (*LASE* indicator Off). Refer to Table 3-5 for output circuit specifications.

Pin 7 Over Temperature

This bi-directional switched output is internally connected to Pin 13, Output Common, when laser temperature is above safe operating limits (*TMP* indicator red). The output is open (high impedance) when laser temperature is within operating limits (*TMP* indicator green). After an over temperature fault occurs, cool the laser and then cycle DC power to reset the laser. Refer to Table 3-5 for output circuit specifications.

Pin 8 Laser Ready

This bi-directional switched output is internally connected to Pin 13, Output Common, when the laser is enabled (*RDY* indicator yellow), indicating that lasing will occur when a PWM Command signal is applied to Pin 9 and Pin 1. When this output is initially switched closed, there is a five-second delay during which lasing is inhibited. This output is open (high impedance) when the laser is disabled (*RDY* indicator Off). Refer to Table 3-5 for output circuit specifications.

Pin 13 Output Common

Use this pin to complete the return (ground) path for any output connection (Pin 6, 7, 8, 14, or 15). The Output Common line is protected by a 0.3 A self-resetting fuse.

Pin 14 Shutter Open

This bi-directional switched output is internally connected to Pin 13, Output Common, when the *Shutter Switch* is Open and a Shutter Open Request signal is present (*SHT* indicator blue), indicating that lasing may be enabled if other operating conditions are met. The output is open (high impedance) when the *Shutter Switch* is Closed or the Shutter Open Request signal is removed. When the Shutter Open output closes (*SHT* indicator blue), there is a five-second delay until PWM inputs are recognized. Refer to Table 3-5 for output circuit specifications.

Pin 15 Interlock Open

This bi-directional switched output is internally connected to Pin 13, Output Common, when remote interlock circuitry is open (*INT* indicator red), indicating that lasing is disabled. The output is open (high impedance) when lasing is enabled (*INT* indicator green). See Table 3-5 for output circuit specifications.

User I/O connections

Figure 3-10 illustrates the output circuit's equivalent internal schematic and Table 3-5 provides Firestar t-Series output circuit specifications.

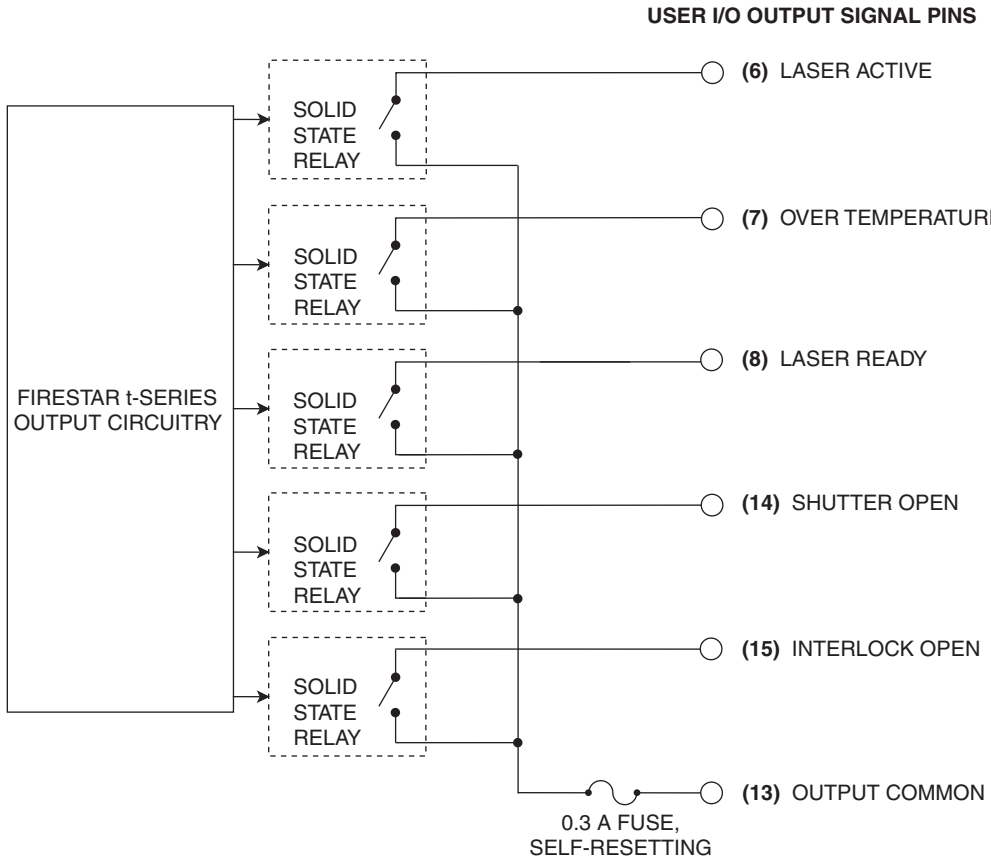


Figure 3-10 Output equivalent schematic

Table 3-5 Output circuit specifications

Output Device	Specifications
Bi-directional MOSFET	20 Ohm Rdson 10 MOhms Off Voltage ±24 VDC, max. Current 50 mA, max.

Sample I/O circuits

Sample inputs

Figure 3-11 illustrates one method of supplying a Remote Interlock signal using a customer-supplied limit switch. Firestar's +24 VDC Auxiliary Power output powers the circuit. Note that Pin 4, +5 VDC Auxiliary Power, could have been used to power the circuit instead, depending on circuit voltage requirements.

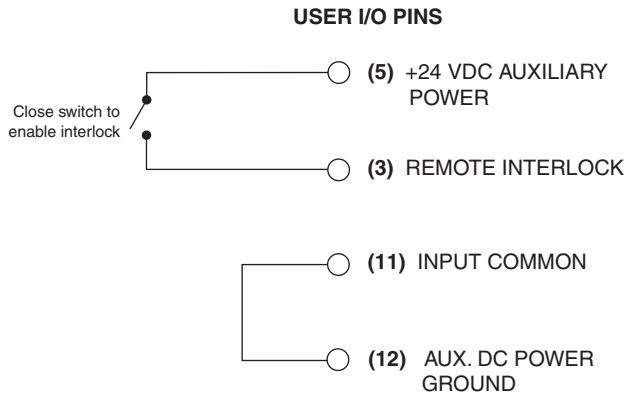

USER I/O PINS
(5) +24 VDC AUXILIARY POWER
Close switch to enable interlock
(3) REMOTE INTERLOCK
(11) INPUT COMMON
(12) AUX. DC POWER GROUND

Figure 3-11 Customer-supplied interlock

Figure 3-12 shows another variation for supplying a Remote Interlock signal to the laser. In this case, the customer is using a switch and supplying a negative voltage to drive Firestar's input circuit.

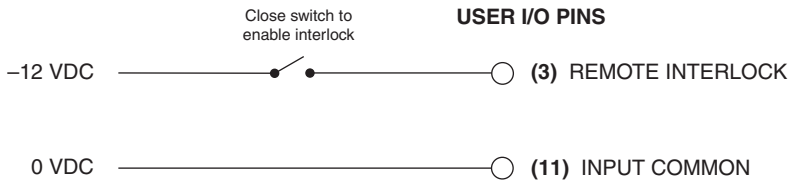


Figure 3-12 Customer-supplied interlock, negative voltage

User I/O connections

A Programmable Logic Controller (PLC) can also drive Firestar inputs. Figure 3-13 shows a typical method for connecting to a PLC output module when only one Firestar input is used.

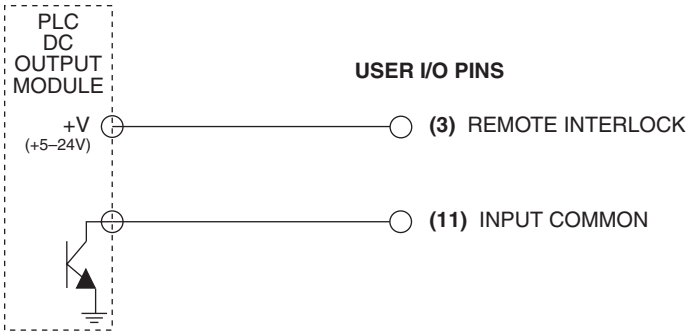


Figure 3-13 PLC driven interlock signal

When multiple PLC outputs are used, connect Firestar inputs to the PLC as shown in Figure 3-14. By supplying voltage (+VDC) to Pin 11, Input Common, and pulling individual inputs to ground, each input can be independently activated by the PLC's output module.

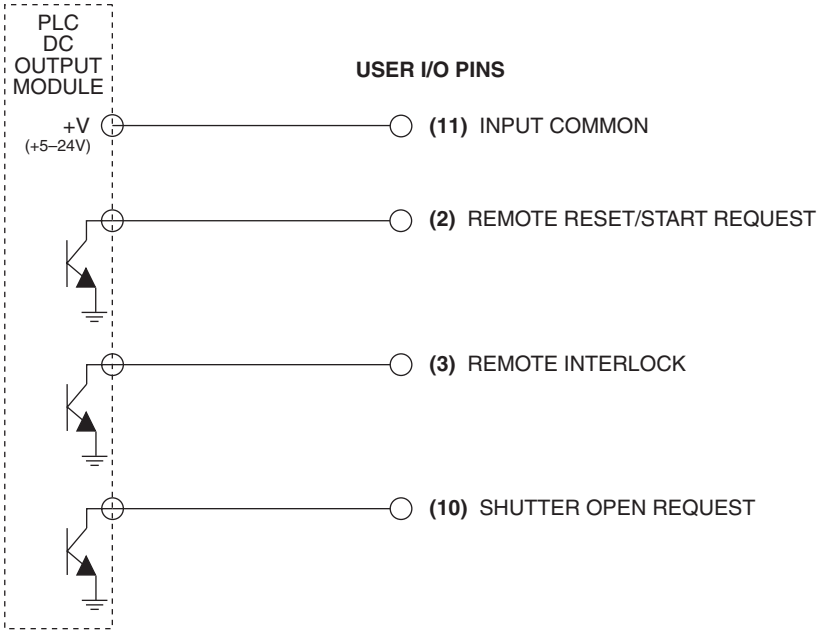


Figure 3-14 Multiple PLC driven inputs

User I/O connections

Sample outputs

Firestar's optoisolated, bi-directional switched outputs can drive small loads (50 mA max), PLC inputs, or relays that can control higher current loads. Figure 3-15 illustrates one method of controlling a remote warning lamp using power supplied by Firestar's +24 VDC Auxiliary Power output. Remember to size current-limiting resistor, R1, so that the current draw does not exceed 50 mA.

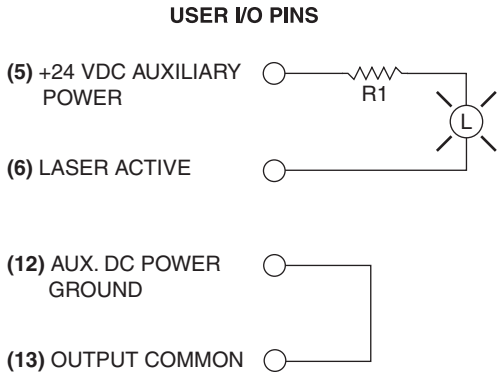


Figure 3-15 Firestar output driving warning lamp

Figure 3-16 illustrates a method for controlling a higher voltage, higher current load by using a 24 V control relay. Ensure that the relay coil's pull-in current does not exceed 50 mA. A diode or surge suppressor must be installed across the relay coil to prevent voltage spikes from damaging Firestar outputs.

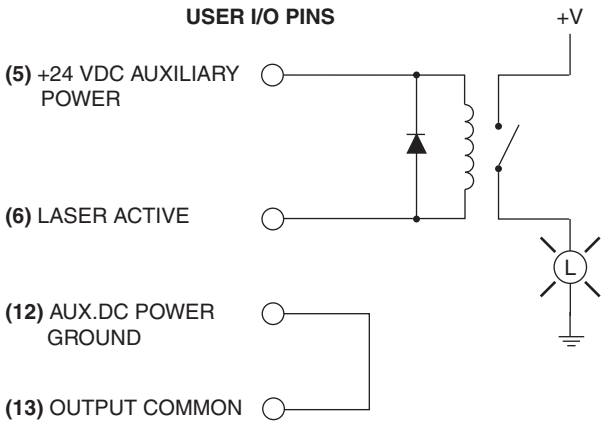


Figure 3-16 Firestar output driving relay

User I/O connections

Figure 3-17 illustrates how Firestar's outputs can drive the DC Input Module of a Programmable Logic Controller (PLC). By supplying voltage (+VDC) to Pin 13, Output Common, each Firestar output is independently switched to activate individual PLC inputs.

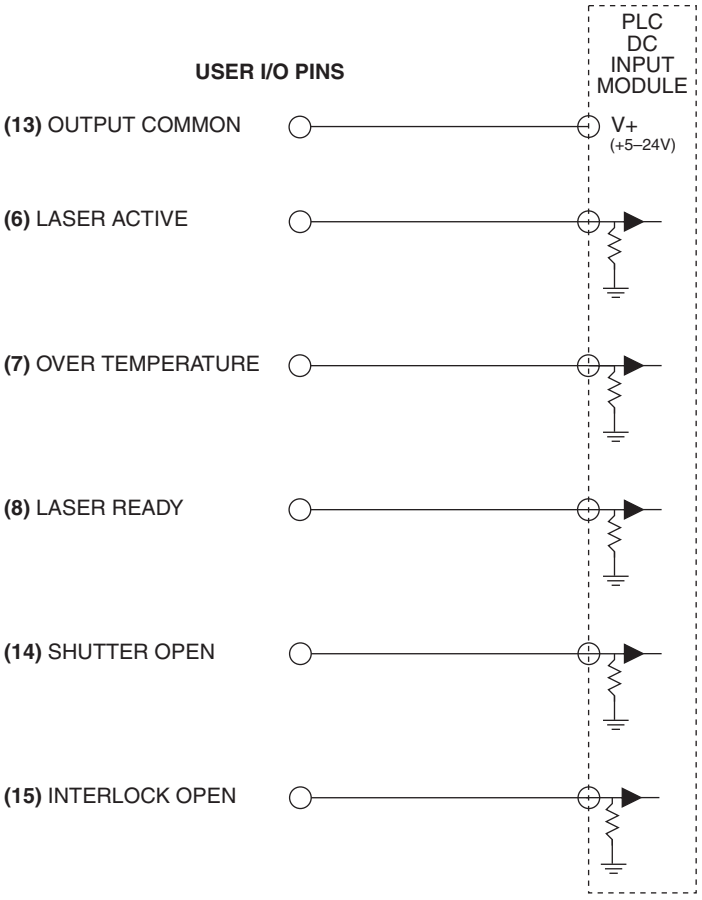


Figure 3-17 Firestar output driving PLC input module

DB-9 connections (SA models only)

The side-mounted DB-9 connector on SA model lasers provides a *Shutter Switch* input as well as auxiliary +5 and +24 VDC power. This connector also provides Lase, Shutter, and Ready signals for driving customer-supplied LEDs. Figure 3-18 illustrates DB-9 pinouts.

Caution possible equipment damage

+24 VDC (Pin 4 and Pin 5) voltage outputs are not fused or electrically protected. Do not short these pins; internal circuitry may be damaged.

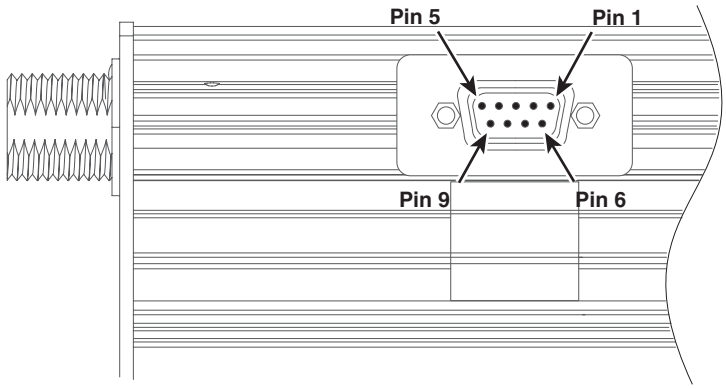


Figure 3-18 DB-9 connector pinouts

Table 3-6 describes the function of each pin on the DB-9 connector.

Table 3-6 Side-mounted DB-9 pin descriptions

Pin	Function	Description
1	Lase	This output activates when the laser is actively lasing (*LASE* indicator illuminates red). This output is only capable of driving an LED for indication purposes. Do not attempt to drive any other electrical device. Figure 3-19 shows how the Lase output is used.
2	No Connection	
3	DC Power Ground	This connection provides a ground (earth) connection for Pin 4 and Pin 5 (+24 VDC Fan Power), and Pin 9 (+5 VDC Auxiliary Power). This pin is the only DB-9 pin connected to chassis ground. Do not use this pin if DC power is supplied from an external customer-supplied DC power source.

technical reference

DB-9 connections (SA models only)

Pin	Function	Description
4	+ 24 VDC Fan Power	This connection provides +24 VDC for driving a customer-supplied cooling fan. The +24 VDC Fan Power output (Pin 4) can source up to 0.75 A max. This pin is not protected or fused; the control board will be damaged if this pin is inadvertently shorted. The return (ground) path must be through Pin 3, DC Power Ground.
5	+ 24 VDC Fan Power	This connection provides +24 VDC for driving a customer-supplied cooling fan. The +24 VDC Fan Power output (Pin 5) can source up to 0.75 A max. This pin is not protected or fused; the control board will be damaged if this pin is inadvertently shorted. The return (ground) path must be through Pin 3, DC Power Ground.
6	Shutter	This output activates when the shutter, if equipped, is Open (*SHT* indicator illuminates blue), indicating that lasing may be enabled if other operating conditions are met. This output is only capable of driving an LED for indication purposes. Do not attempt to drive any other electrical device. Figure 3-19 shows how the Shutter output is used.
7	Ready	This output activates when the laser is enabled (*RDY* indicator illuminates yellow), indicating that, after a five-second delay, lasing will occur when a PWM Command signal is applied provided that other operating conditions are met. This output is only capable of driving an LED for indication purposes. Do not attempt to drive any other electrical device. Figure 3-19 shows how the Ready output is used.
8	Shutter Switch	In keyswitch models, this input connects to the physical *Shutter Switch*. Leave this input open to enable lasing. Grounding this pin indicates that the shutter is Closed, which disables lasing. If connecting an external shutter switch to Pin 8, the circuit path must be grounded to Pin 3, DC Power Ground. There is a five-second delay imposed from the time the shutter input is opened to the time that PWM Command signals are accepted.
9	+ 5 VDC Auxiliary Power	This connection provides +5 VDC for driving external inputs or outputs. The +5 VDC Auxiliary Power output (Pin 9) can source up to 0.5 A maximum and is protected by a self-resetting fuse. The return (ground) path must be through Pin 3, DC Power Ground.

DB-9 connections (SA models only)

Figure 3-19 shows how to connect LED indicators to Ready, Lase, and Shutter outputs. The DB-9 circuit is designed so that no external current-limiting resistors are required.

Note: The Shutter output circuit is designed to drive only blue, white, or purple LEDs. You must add an external 43 Ohm resistor if an LED of another color is used.

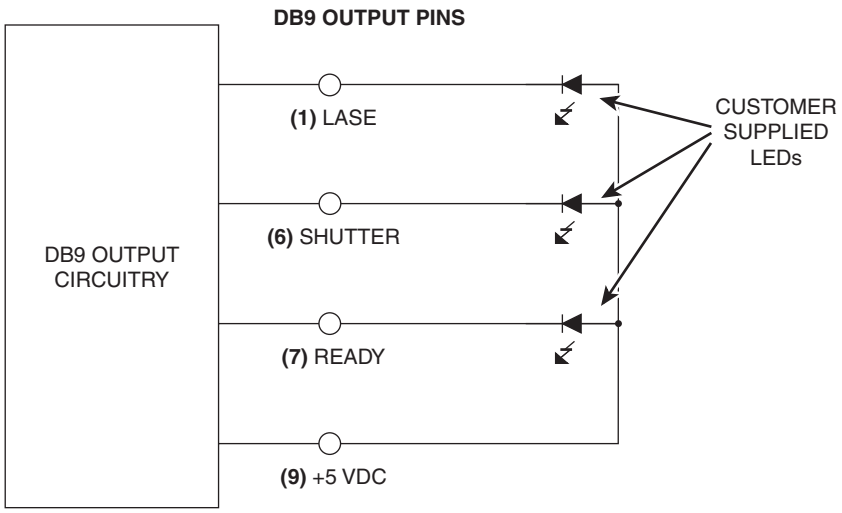


Figure 3-19 DB-9 output circuit

technical reference

Integrating Firestar safety features

The *Integrating Firestar safety features* section includes subsections:

- Keyswitch functions
- Shutter functions
- Remote Interlock functions

Firestar's DB-15 *User I/O* connector allows system integrators or end-users to integrate Firestar safety features into their control system. Firestar's keyswitch, shutter, and remote interlock functions serve to enable or disable DC power to Firestar's RF drive. Without DC power, the RF driver cannot supply RF energy to the resonator, causing the CO_2 gas to remain in a zero-energy state. Firestar status indicators provide users with a quick visual indication of the laser's operational status. All power to the laser's RF board is removed whenever *RDY* or *SHT* indicators are Off (Laser Ready or Shutter Open outputs open).

Keyswitch functions

Keyswitch lasers

After DC power-up or after a remote interlock fault, the *Keyswitch* must be toggled OFF/ON to reset the laser and enable the *RDY* LED, signaling that DC power is applied to the RF driver. Over temperature faults are reset by removing, then reapplying DC power after the laser has cooled.

For *Keyswitch*-equipped lasers used in automated systems, this keyswitch/reset function is available via the Remote Reset/Start Request input on Pin 2 of the *User I/O* connector. To use this "remote keyswitch" functionality, first place the *Keyswitch* in the ON position. Then after each DC power-up cycle (or to reset a fault condition), apply a momentary voltage pulse in the range of ±5–24 VDC to Pin 2, the Remote Reset/Start Request input. Removing voltage allows DC power to reach the RF driver and begins a five-second delay after which lasing is enabled (*RDY* LED illuminates yellow). The RF driver is disabled as long as voltage is applied to Pin 2.

Your control system can monitor the laser's ready status on the *User I/O* connector by connecting your system's input between Pin 8, Laser Ready, and Pin 13, Output Common (see Figure 3-17). The Laser Ready output closes when the laser is enabled (*RDY* LED illuminated yellow), indicating that lasing is possible. The output is open (in a high-impedance state) and the *RDY* LED is off when lasing is disabled.

Note: After the Laser Ready output closes, a five-second delay occurs before lasing is enabled.

OEM lasers

On OEM lasers, the *RDY* LED illuminates on DC power-up (provided that Shutter Open Request and Remote Interlock inputs are enabled) and five seconds later, DC power is applied to the RF driver. Over temperature faults are reset by removing and then re-applying DC power after the laser has cooled. Remote interlock faults are not latched; the *RDY* LED illuminates yellow as soon as the interlock circuit is closed (when the *INT* LED turns from red to green) and five seconds later lasing is enabled.

Although a Remote Reset/Start Request input is not needed to reset OEM faults, it can be used to inhibit (disable) lasing. Disable the laser by applying a voltage in the range of ±5–24 VDC to Pin 2, the Remote Reset/Start Request input. Removing voltage allows power to reach the RF driver and begins a five-second countdown after which lasing is enabled (*RDY* LED illuminates yellow). The RF driver is disabled as long as voltage is applied to Pin 2.

Your control system can monitor the laser's ready status on the *User I/O* connector by connecting your system's input between Pin 8, Laser Ready, and Pin 13, Output Common (see Figure 3-17).

Integrating Firestar safety features

The Laser Ready output closes when the laser is enabled (*RDY* LED illuminated yellow), indicating that lasing is possible. The output is open (in a high-impedance state) and the *RDY* LED is off when lasing is disabled.

Note: After the Laser Ready output closes, a five-second delay occurs before lasing is enabled.

Shutter functions

A mechanical *Shutter Switch* is installed on all *Keyswitch*-equipped lasers. Lasing is enabled when the shutter is Open (*SHT* LED illuminated blue) and disabled when the shutter is Closed (*SHT* LED off). The *SHT* LED illuminates blue to indicate that DC power is applied to the RF driver.

For t-Series OEM and *Keyswitch*-equipped lasers in automated systems, the shutter function is provided by the Shutter Open Request signal via Pin 10 on the *User I/O* connector. To use this "remote shutter", first place the *Shutter Switch* (if equipped) in the Open position and then apply a voltage in the range of ±5–24 VDC to Pin 10, Shutter Open Request. This input signal causes the *SHT* LED to illuminate and sends DC power to the RF driver, enabling lasing after a five-second delay. Lasing is disabled until the manual *Shutter Switch* is placed in the Open position and a Shutter Open Request signal is applied to Pin 10.

Your control system can monitor the laser's shutter status on the *User I/O* connector by connecting your system's input between Pin 14, Shutter Open, and Pin 13, Output Common (see Figure 3-17). The Shutter Open output closes when the *Shutter Switch* is Open and a Shutter Open Request signal is present (*SHT* LED illuminated blue). The output is open (in a high-impedance state) and the *SHT* LED is off when the *Shutter Switch* is Closed or the Shutter Open Request signal is removed.

Note: After the Shutter Open output closes, a five-second delay occurs before lasing is enabled.

Remote interlock functions

Interlock circuits are often used to disable machinery when a shield, panel, or door is opened. Firestar's remote interlock function allows you to connect into an external remote interlock circuit and prevent lasing by removing DC power from the laser's RF driver boards when the circuit is electrically "open".

Lasing is enabled when a Remote Interlock signal is present (*INT* LED illuminated green), if *RDY* and *SHT* LEDs are illuminated and disabled when the Remote Interlock signal is removed (*INT* LED red, *RDY* LED off). DC power is applied to the RF driver only when the *INT* LED is green and the *RDY* LED is yellow (and the *SHT* LED is illuminated blue). Remote interlock functionality is provided by the Remote Interlock signal via Pin 3 on the *User I/O* connector.

To use Firestar's remote interlock feature, apply a voltage in the range of ±5–24 VDC to Pin 3, Remote Interlock. Applying an interlock signal causes the *INT* LED to illuminate green and sends DC power to the RF driver, which enables lasing after a five-second delay (provided that the *RDY* LED is yellow and the *SHT* LED is blue). Removing the interlock signal removes DC power from the RF driver, causing the *INT* LED to turn red and the *RDY* LED to turn off. Lasing remains disabled until a Remote Interlock signal is reapplied to Pin 3.

Your control system can monitor the laser's remote interlock status on the *User I/O* connector by connecting your system's input between Pin 15, Interlock Open, and Pin 13, Output Common (see Figure 3-17). This output is closed when remote interlock circuitry is open (*INT* indicator illuminated red). The output is open (in a high-impedance state) and the *INT* LED is green when interlock circuitry is closed.

Note: After the Interlock Open output opens, a five-second delay occurs before lasing is enabled.

technical reference

t60 general specifications

Table 3-7 Firestar t60 general specifications

Parameter	Firestar t60		
Output Specifications			
Wavelength†	10.57–10.63 microns		
Power Output[1, 2, 3]	60 Watts		
Power Stability[4]	± 7%		
Mode Quality	$M^2 \leq 1.2$		
Beam Waist Diameter (at $1/e^2$)[5]	2.2 ±0.2 mm		
Beam Divergence, full angle (at $1/e^2$)[5]	< 7 mrad		
Ellipticity	< 1.2		
Polarization	Linear, vertical		
Extinction Ratio	> 100:1		
Rise Time	< 75 µs		
Modulation (Optical response)	up to 25 kHz		
Input Specifications			
Power Supply			
Voltage	30 VDC		
Maximum Current	45 A		
Command Input Signal			
Voltage	+3.5 to +6.7 VDC		
Current	10 mA @ +6.7 VDC		
Frequency[6]	DC–25 kHz		
Duty Cycle	0%–100%		
Logic Low State (Vmin–Vmax)	0.0 to +0.8 VDC		
Logic High State (Vmin–Vmax)	+3.5 to +6.7 VDC		
Cooling Specifications	(Air-cooled)		(Water-cooled)
Maximum Heat Load, Laser Head	700 Watts		700 Watts
, RF-600	700 Watts		700 Watts
Minimum Flow Rate	130 CFM per fan (×2)		0.75–2.0 GPM, < 60 PSI
rear air-cooled	> 300 CFM		N/A
Coolant Temperature	≤ 40 °C, ambient		18–22 °C

* Specifications subject to change without notice.

† Typical. Actual wavelength range may vary from 10.2–10.8 µm.

1 This power level is guaranteed for 12 months regardless of operating hours.

2 Minimum 30 VDC input voltage to obtain guaranteed output power.

3 With two-meter RF cable length.

4 From cold start (guaranteed).

5 Measured at laser output.

6 Tested at 5 kHz.

technical reference

t60 general specifications

Parameter	Firestar t60
Environmental Specifications	
Operating Ambient Temperature Range[7]	15–40 °C
Humidity	0–95%, non-condensing
Physical Specifications	
t60, water-cooled (KWB, SWB models)	
Length	22.98 in (58.4 cm)
Width	5.62 in (14.3 cm)
Height	6.10 in (15.5 cm)
Weight	24.0 lbs (10.9 kg)
RF-600, water-cooled	
Length	12.00 in (30.5 cm)
including mounting bracket	12.97 in (32.9 cm)
Width	12.00 in (30.5 cm)
Height	3.31 in (8.4 cm)
including mounting bracket	3.54 in (9.0 cm)
Weight	17.0 lbs (7.71 kg)
including mounting bracket	19.0 lbs (8.62 kg)
t60, fan-cooled (KFB, SFB models)	
Length	22.46 in (57.1 cm)
Width	7.72 in (19.6 cm)
Height	6.27 in (15.9 cm)
Weight	26.0 lbs (11.8 kg)
RF-600, fan-cooled	
Length	12.0 in (30.5 cm)
including mounting bracket	12.97 in (32.9 cm)
Width	12.15 in (30.9 cm)
Height	5.91 in (15.0 cm)
including mounting bracket	6.14 in (15.6 cm)
Weight	19.5 lbs (8.85 kg)
including mounting bracket	21.5 lbs (9.75 kg)

* Specifications subject to change without notice.

7 Published specifications guaranteed at a cooling temperature of 22 °C. For t-Series lasers, some performance degradation may occur when operated in ambient air or cooling water temperatures above 22 °C. With air-cooled lasers, output laser power typically decreases 0.5–1% per degree Celsius increase in ambient temperature.

technical reference

t60 general specifications

Parameter	Firestar t60
Physical Specifications (cont.)	
t60, air-cooled (SAD models)	
Length	22.46 in (57.1 cm)
Width	6.22 in (15.8 cm)
Height	5.84 in (14.8 cm)
Weight	22.5 lbs (10.2 kg)
RF-600, fan-cooled	
Length	12.0 in (30.5 cm)
including mounting bracket	12.97 in (32.9 cm)
Width	12.15 in (30.9 cm)
Height	5.91 in (15.0 cm)
including mounting bracket	6.14 in (15.6 cm)
Weight	19.5 lbs (8.85 kg)
including mounting bracket	21.5 lbs (9.75 kg)

* Specifications subject to change without notice.

t80 general specifications

Table 3-8 Firestar t80 general specifications

Parameter	Firestar t80		
Output Specifications			
Wavelength†	10.57–10.63 microns		
Power Output[1, 2, 3]	80 Watts		
Power Stability[4]	± 7%		
Mode Quality	$M^2 \leq 1.2$		
Beam Waist Diameter (at $1/e^2$)[5]	2.2 ±0.2 mm		
Beam Divergence, full angle (at $1/e^2$)[5]	< 7 mrad		
Ellipticity	< 1.2		
Polarization	Linear, vertical		
Extinction Ratio	> 100:1		
Rise Time	< 75 µs		
Modulation (Optical response)	up to 25 kHz		
Input Specifications			
Power Supply			
Voltage	36 VDC		
Maximum Current	55 A		
Command Input Signal			
Voltage	+3.5 to +6.7 VDC		
Current	10 mA @ +6.7 VDC		
Frequency[6]	DC–25 kHz		
Duty Cycle	0%–100%		
Logic Low State (Vmin–Vmax)	0.0 to +0.8 VDC		
Logic High State (Vmin–Vmax)	+3.5 to +6.7 VDC		
Cooling Specifications	(Air-cooled)		(Water-cooled)
Maximum Heat Load, Laser Head	1000 Watts		1000 Watts
, RF-800	1000 Watts		1000 Watts
Minimum Flow Rate	195 CFM per fan (×2, centered)		0.75–2.0 GPM, < 60 PSI
rear air-cooled	N/A		N/A
Coolant Temperature	≤ 40 °C, ambient		18–22 °C

* Specifications subject to change without notice.

† Typical. Actual wavelength range may vary from 10.2–10.8 µm.

1 This power level is guaranteed for 12 months regardless of operating hours.

2 Minimum 36 VDC input voltage to obtain guaranteed output power.

3 With two-meter RF cable length.

4 From cold start (guaranteed).

5 Measured at laser output.

6 Tested at 5 kHz.

technical reference

t80 general specifications

Parameter	Firestar t80
Environmental Specifications	
Operating Ambient Temperature Range[7]	15–40 °C
Humidity	0–95%, non-condensing
Physical Specifications	
t80, water-cooled (KWB, SWB models)	
Length	22.98 in (58.4 cm)
Width	5.62 in (14.3 cm)
Height	6.10 in (15.5 cm)
Weight	24.0 lbs (10.9 kg)
RF-800, water-cooled	
Length	12.00 in (30.5 cm)
including mounting bracket	12.97 in (32.9 cm)
Width	12.00 in (30.5 cm)
Height	3.31 in (8.4 cm)
including mounting bracket	3.54 in (9.0 cm)
Weight	17.0 lbs (7.71 kg)
including mounting bracket	19.0 lbs (8.62 kg)
t80, fan-cooled (KFB, SFB models)	
Length	22.46 in (57.1 cm)
Width	7.72 in (19.6 cm)
Height	6.27 in (15.9 cm)
Weight	26.0 lbs (11.8 kg)
RF-800, fan-cooled	
Length	12.0 in (30.5 cm)
including mounting bracket	12.97 in (32.9 cm)
Width	12.15 in (30.9 cm)
Height	5.91 in (15.0 cm)
including mounting bracket	6.14 in (15.6 cm)
Weight	19.5 lbs (8.85 kg)
including mounting bracket	21.5 lbs (9.75 kg)

* Specifications subject to change without notice.

7 Published specifications guaranteed at a cooling temperature of 22 °C. For t-Series lasers, some performance degradation may occur when operated in ambient air or cooling water temperatures above 22 °C. With air-cooled lasers, output laser power typically decreases 0.5–1% per degree Celsius increase in ambient temperature.

t80 general specifications

Parameter	Firestar t80
Physical Specifications (cont.)	
t80, air-cooled (SAD models)	
Length	22.46 in (57.1 cm)
Width	6.22 in (15.8 cm)
Height	5.84 in (14.8 cm)
Weight	22.5 lbs (10.2 kg)
RF-800, fan-cooled	
Length	12.0 in (30.5 cm)
including mounting bracket	12.97 in (32.9 cm)
Width	12.15 in (30.9 cm)
Height	5.91 in (15.0 cm)
including mounting bracket	6.14 in (15.6 cm)
Weight	19.5 lbs (8.85 kg)
including mounting bracket	21.5 lbs (9.75 kg)

* Specifications subject to change without notice.

technical reference

t100 general specifications

Table 3-9 Firestar t100 general specifications

Parameter	Firestar t100	
Output Specifications		
Wavelength†	10.57–10.63 microns	
Power Output[1, 2, 3]	100 Watts	
Power Stability[4]	± 7%	
Mode Quality	$M^2 \leq 1.2$	
Beam Waist Diameter (at $1/e^2$)[5]	2.2 ±0.2 mm	
Beam Divergence, full angle (at $1/e^2$)[5]	< 7 mrad	
Ellipticity	< 1.2	
Polarization	Linear, vertical	
Extinction Ratio	> 100:1	
Rise Time	< 75 µs	
Modulation (Optical response)	up to 25 kHz	
Input Specifications		
Power Supply		
Voltage	30 VDC	
Maximum Current	75 A	
Command Input Signal		
Voltage	+3.5 to +6.7 VDC	
Current	10 mA @ +6.7 VDC	
Frequency[6]	DC–25 kHz	
Duty Cycle	0%–100%	
Logic Low State (Vmin–Vmax)	0.0 to +0.8 VDC	
Logic High State (Vmin–Vmax)	+3.5 to +6.7 VDC	
Cooling Specifications	(Air-cooled)	(Water-cooled)
Maximum Heat Load, Laser Head	1150 Watts	1150 Watts
, RF-1000	1150 Watts	1150 Watts
Minimum Flow Rate	195 CFM per fan (×2, centered)	0.75–2.0 GPM, < 60 PSI
rear air-cooled	N/A	N/A
Coolant Temperature	≤ 40 °C, ambient	18–22 °C

* Specifications subject to change without notice.

† Typical. Actual wavelength range may vary from 10.2–10.8 µm.

1 This power level is guaranteed for 12 months regardless of operating hours.

2 Minimum 30 VDC input voltage to obtain guaranteed output power.

3 With two-meter RF cable length.

4 From cold start (guaranteed).

5 Measured at laser output.

6 Tested at 5 kHz.

technical reference

t100 general specifications

Parameter	Firestar t100
Environmental Specifications	
Operating Ambient Temperature Range[7]	15–40 °C
Humidity	0–95%, non-condensing
Physical Specifications	
t100, water-cooled (KWB, SWB models)	
Length	22.98 in (58.4 cm)
Width	5.62 in (14.3 cm)
Height	6.10 in (15.5 cm)
Weight	24.0 lbs (10.9 kg)
RF-1000, water-cooled	
Length	17.5 in (44.4 cm)
Width	13.0 in (33.0 cm)
including mounting bracket	14.1 in (35.8 cm)
Height	4.20 in (10.7 cm)
including mounting bracket	4.54 in (11.5 cm)
Weight	34.0 lbs (15.4 kg)
including mounting bracket	36.0 lbs (16.3 kg)
t100, fan-cooled (KFB, SFB models)	
Length	22.46 in (57.1 cm)
Width	7.72 in (19.6 cm)
Height	6.27 in (15.9 cm)
Weight	26.0 lbs (11.8 kg)
RF-1000, fan-cooled	
Length	17.5 in (44.4 cm)
Width	13.0 in (33.0 cm)
including mounting bracket	14.1 in (35.8 cm)
Height	6.44 in (16.4 cm)
including mounting bracket	6.78 in (17.2 cm)
Weight	30.0 lbs (13.6 kg)
including mounting bracket	32.0 lbs (14.5 kg)

* Specifications subject to change without notice.

7 Published specifications guaranteed at a cooling temperature of 22 °C. For t-Series lasers, some performance degradation may occur when operated in ambient air or cooling water temperatures above 22 °C. With air-cooled lasers, output laser power typically decreases 0.5–1% per degree Celsius increase in ambient temperature.

technical reference

t100 general specifications

Parameter	Firestar t100
Physical Specifications (cont.)	
t100, air-cooled (SAD models)	
Length	22.46 in (57.1 cm)
Width	6.22 in (15.8 cm)
Height	5.84 in (14.8 cm)
Weight	22.5 lbs (10.2 kg)
RF-1000, fan-cooled	
Length	17.5 in (44.4 cm)
Width	13.0 in (33.0 cm)
including mounting bracket	14.1 in (35.8 cm)
Height	6.44 in (16.4 cm)
including mounting bracket	6.78 in (17.2 cm)
Weight	30.0 lbs (13.6 kg)
including mounting bracket	32.0 lbs (14.5 kg)

* Specifications subject to change without notice.

Firestar t-Series package outline drawings

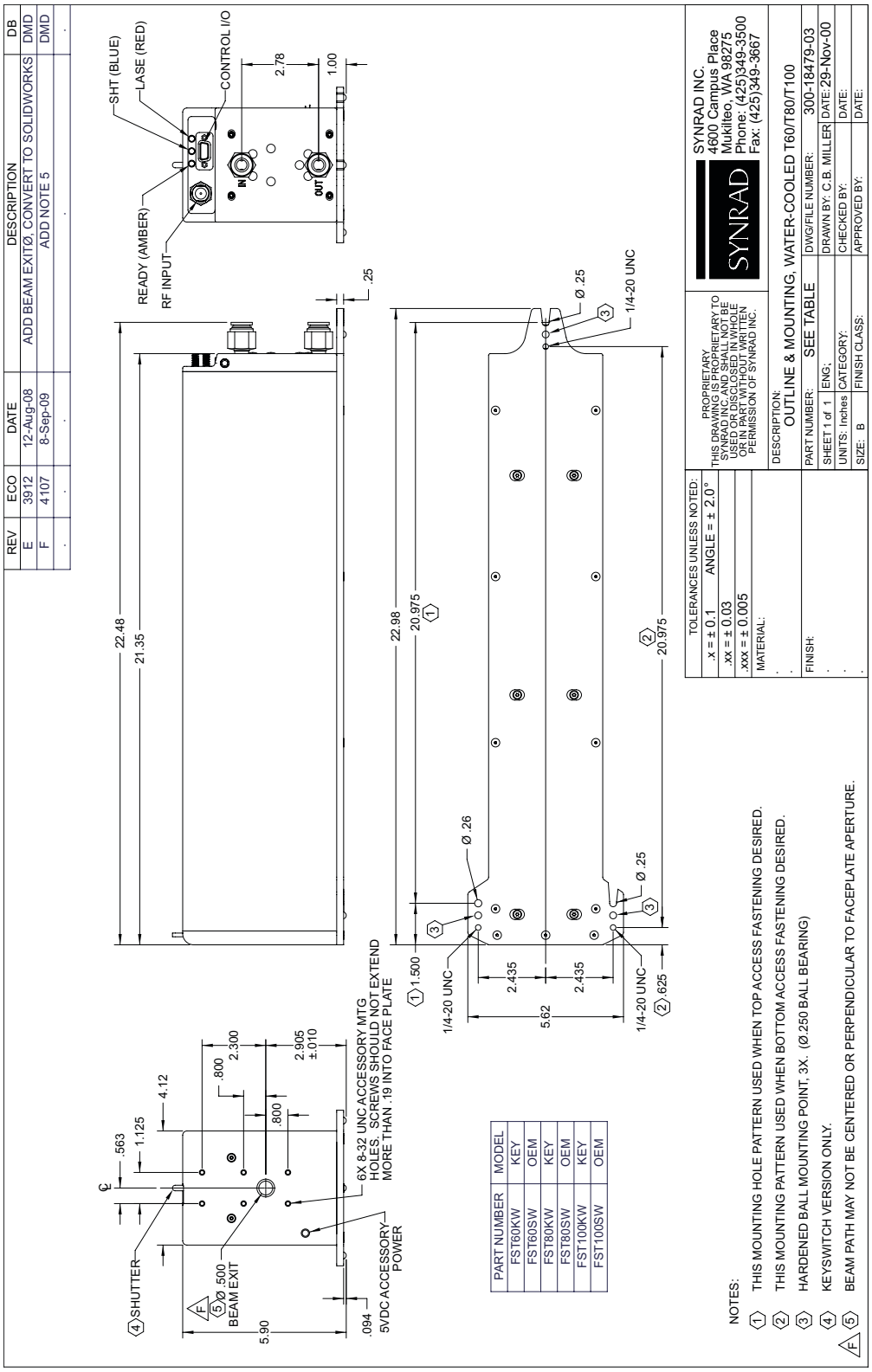


Figure 3-20 Water-cooled Firestar t60/t80/t100 package outline and mounting dimensions

Firestar t-Series package outline drawings

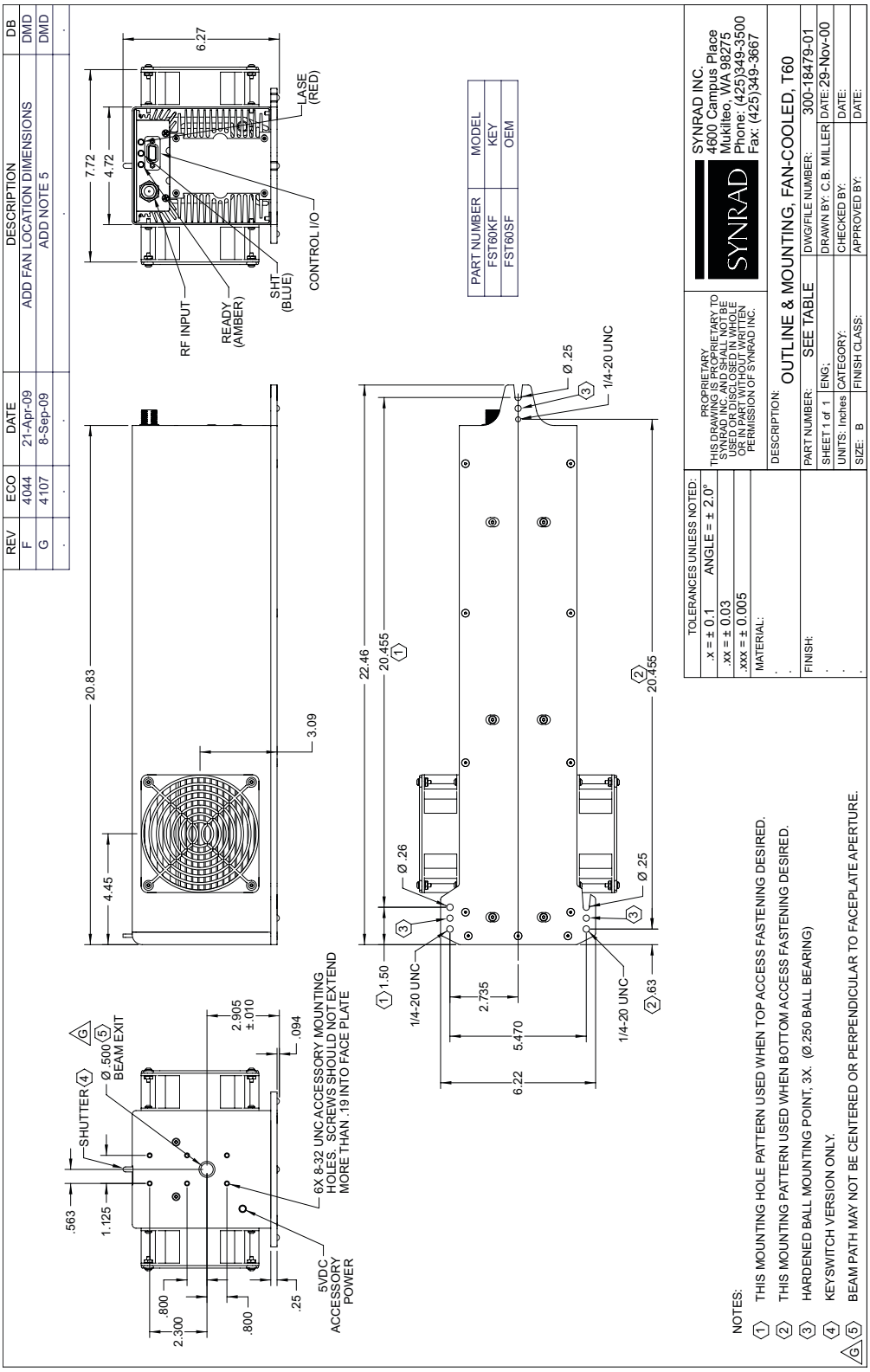


Figure 3-21 Fan-cooled Firestar t60 package outline and mounting dimensions

Firestar t-Series package outline drawings

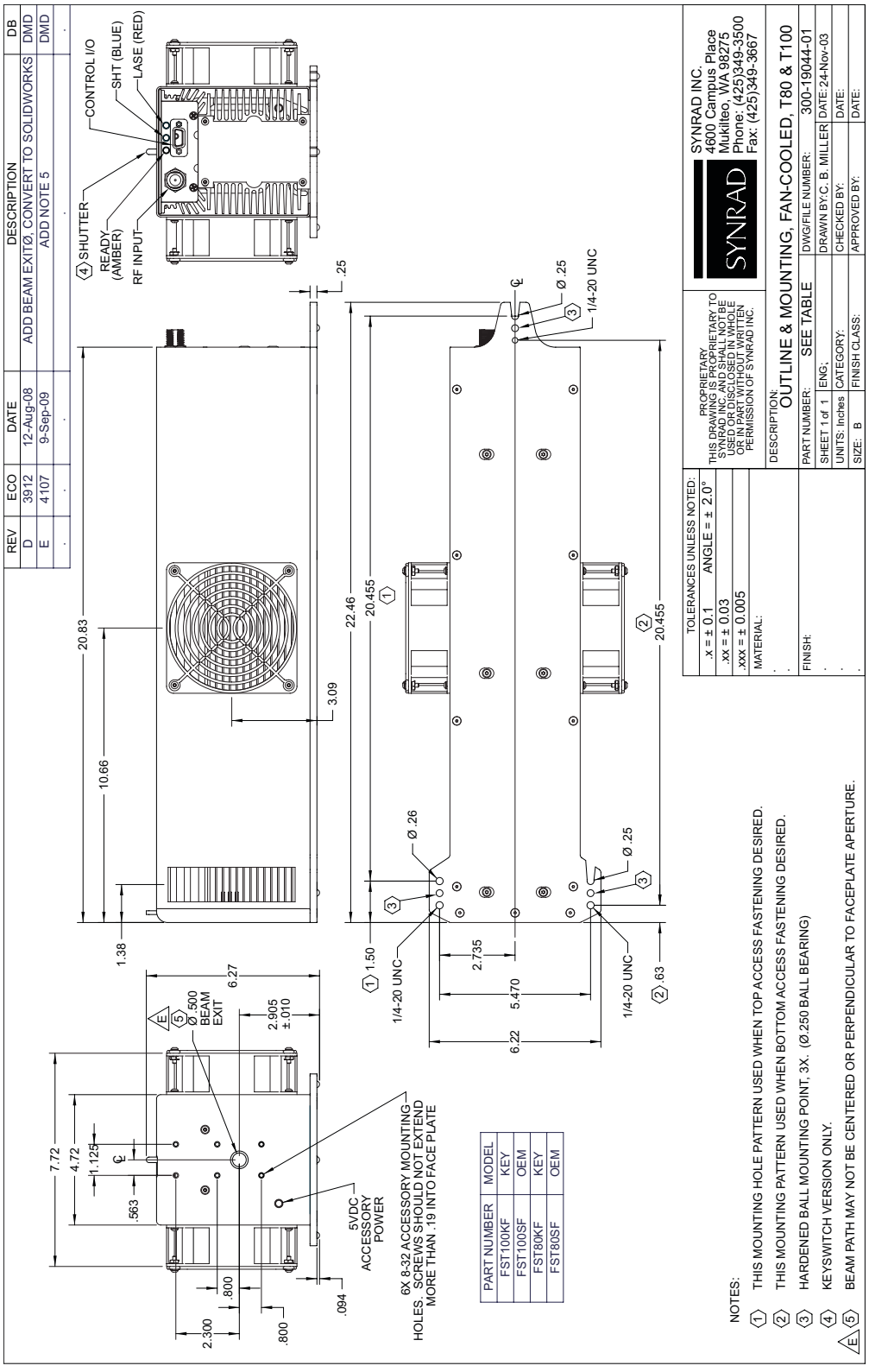


Figure 3-22 Fan-cooled Firestar t80/t100 package outline and mounting dimensions

Firestar t-Series package outline drawings

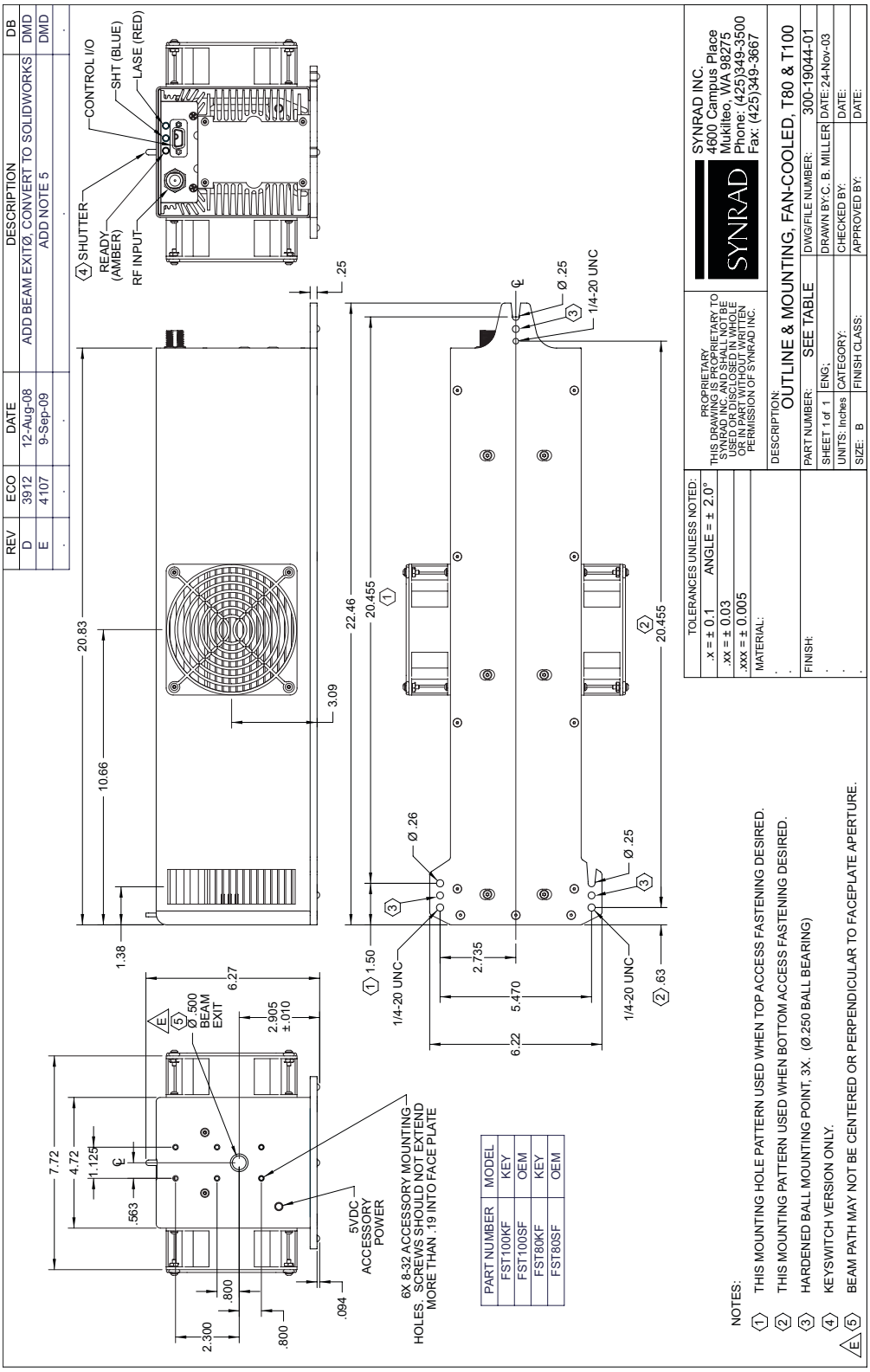


Figure 3-23 Air-cooled Firestar t60/t80/t100 (SA model) package outline and mounting dimensions

RF-600/RF-800 package outline drawings

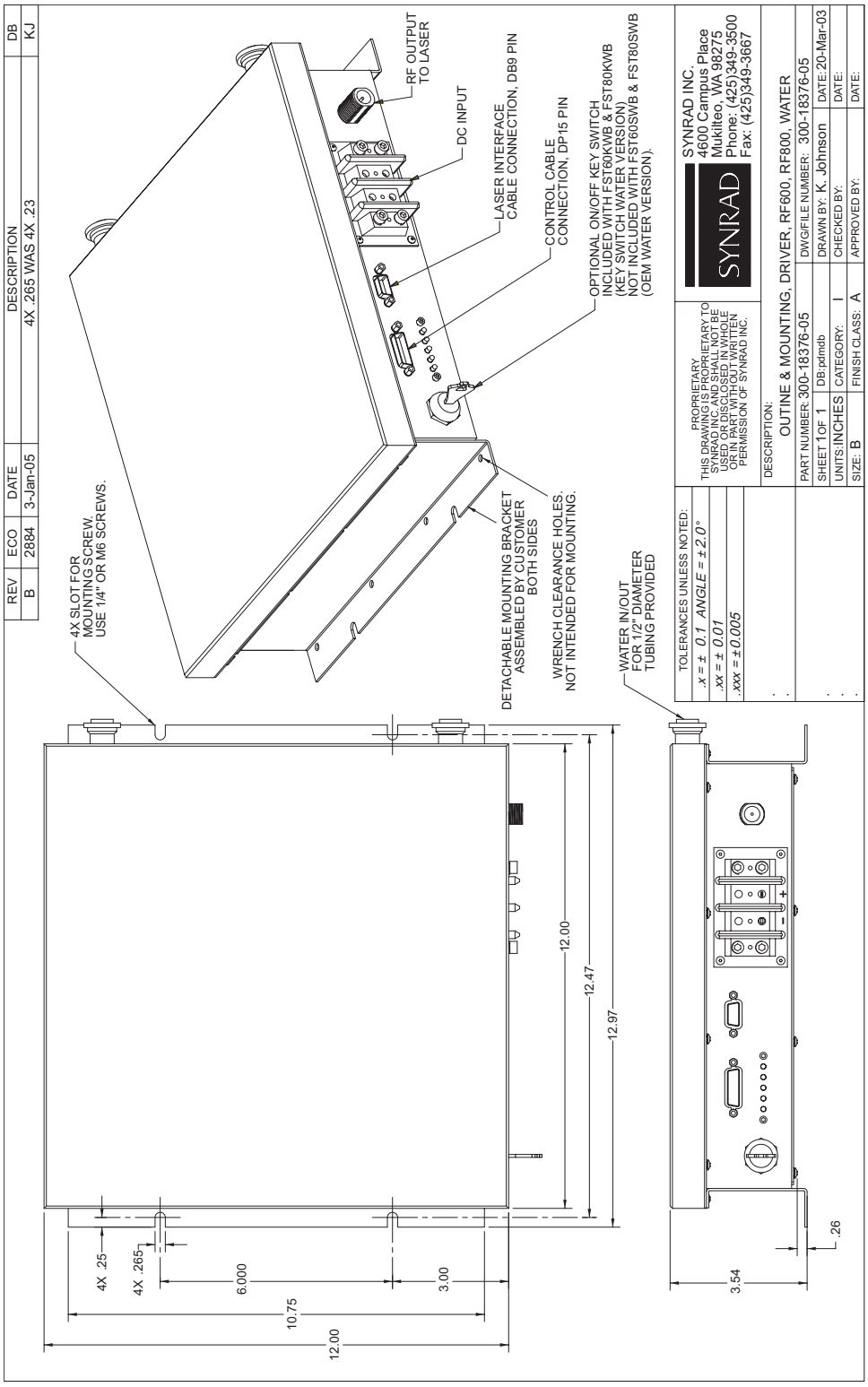

REV | ECO | DATE | DESCRIPTION | DB
B | 2884 | 3-Jan-05 | 4X .265 WAS 4X .23 | KJ
4X SLOT FOR MOUNTING SCREW, USE 1/4" OR M6 SCREWS.
RF OUTPUT TO LASER
DC INPUT
LASER INTERFACE CABLE CONNECTION, DB9 PIN
CONTROL CABLE CONNECTION, DP15 PIN
OPTIONAL ON/OFF KEY SWITCH INCLUDED WITH FST60KWB & FST80KWB (KEY SWITCH WATER VERSION) NOT INCLUDED WITH FST60SWB & FST80SWB (OEM WATER VERSION).
DETACHABLE MOUNTING BRACKET ASSEMBLED BY CUSTOMER BOTH SIDES
WRENCH CLEARANCE HOLES. NOT INTENDED FOR MOUNTING.
WATER IN/OUT FOR 1/2" DIAMETER TUBING PROVIDED
SYNRAD INC.
4600 Campus Place
Mukilteo, WA 98275
Phone: (425)349-3500
Fax: (425)349-3667
SYNRAD
PROPRIETARY
THIS DRAWING IS PROPRIETARY TO SYNRAD INC. AND SHALL NOT BE USED OR DISCLOSED IN WHOLE OR IN PART WITHOUT WRITTEN PERMISSION OF SYNRAD INC.
DESCRIPTION: OUTINE & MOUNTING, DRIVER, RF600, RF800, WATER
PART NUMBER: 300-18376-05
SHEET 1 OF 1
UNITS: INCHES
SIZE: B
DWG/FILE NUMBER: 300-18376-05
DRAWN BY: K. Johnson
DATE: 20-Mar-03
CHECKED BY:
DATE:
CATEGORY: I
FINISH CLASS: A
APPROVED BY:
DATE:
TOLERANCES UNLESS NOTED:
.x = ± 0.1 ANGLE = ± 2.0°
.xx = ± 0.01
.xxx = ± 0.005
12.00
12.47
12.97
4X .25
4X .265
6.000
3.00
10.75
12.00
3.54
.26

Figure 3-24 Water-cooled RF-600/RF-800 package outline and mounting dimensions

RF-600/RF-800 package outline drawings

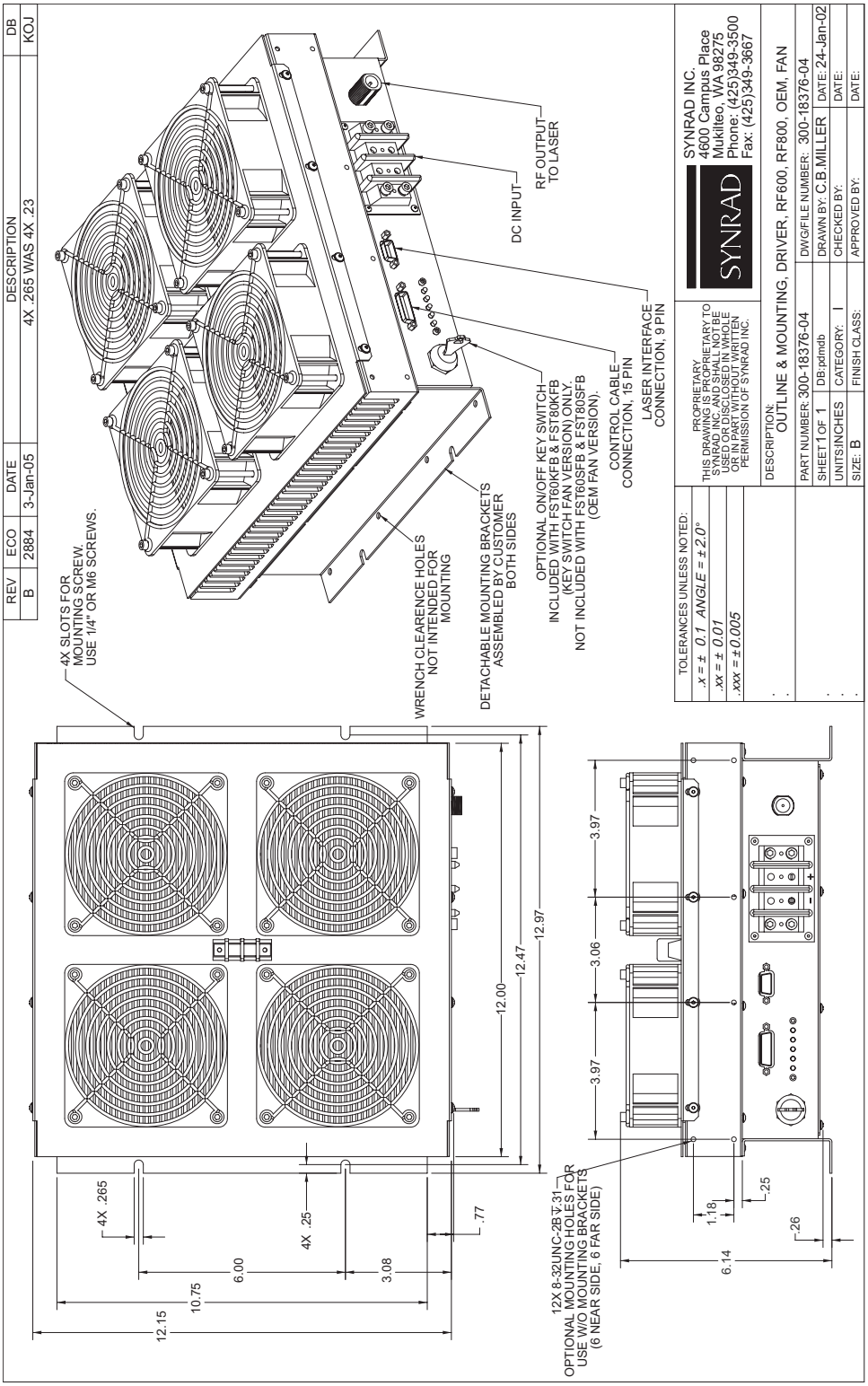


Figure 3-25 Fan-cooled RF-600/RF-800 package outline and mounting dimensions

RF-1000 package outline drawings

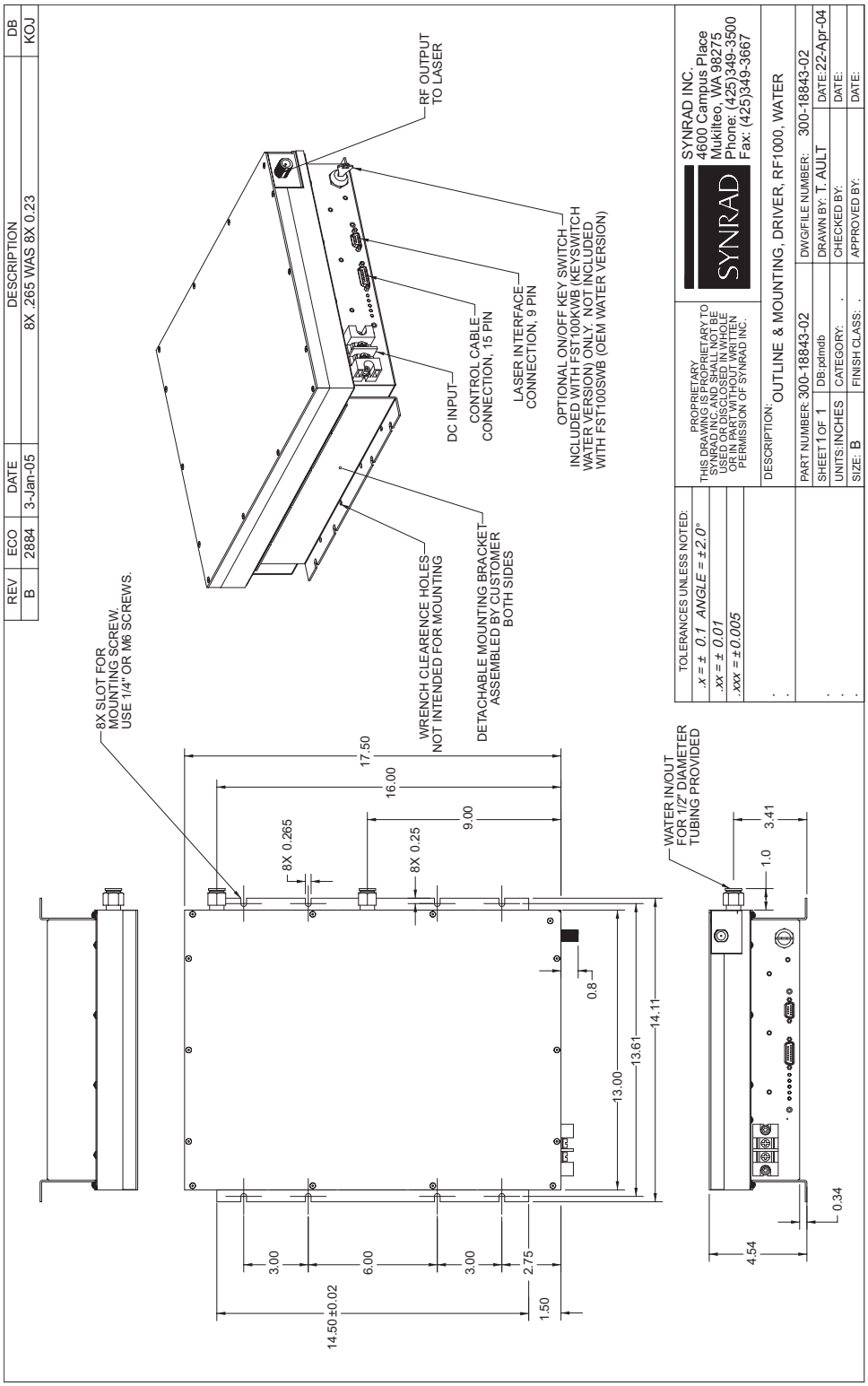


Figure 3-26 Water-cooled RF-1000 package outline and mounting dimensions

technical reference

RF-1000 package outline drawings

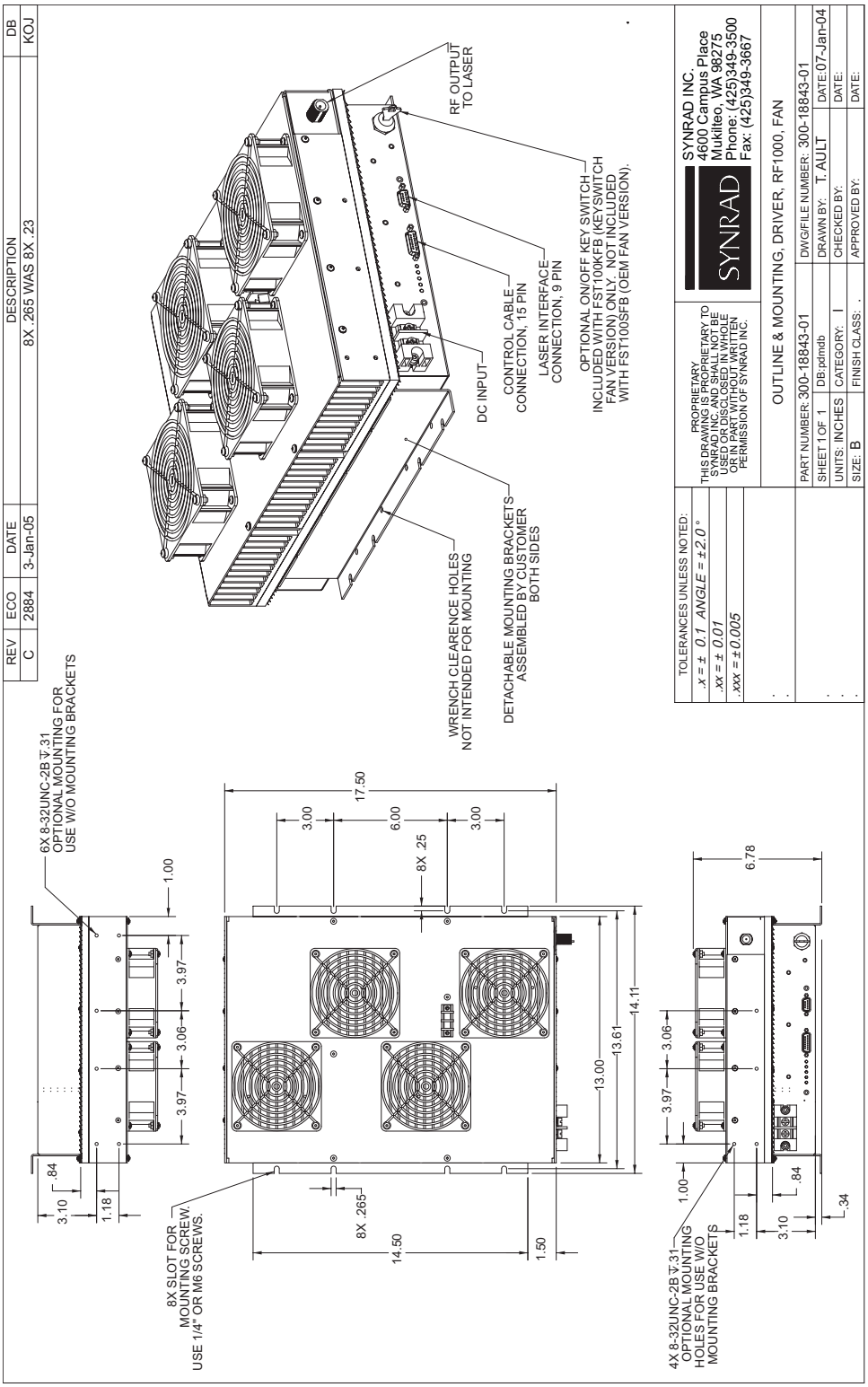


Figure 3-27 Fan-cooled RF-1000 package outline and mounting dimensions

t-Series cable outline drawings

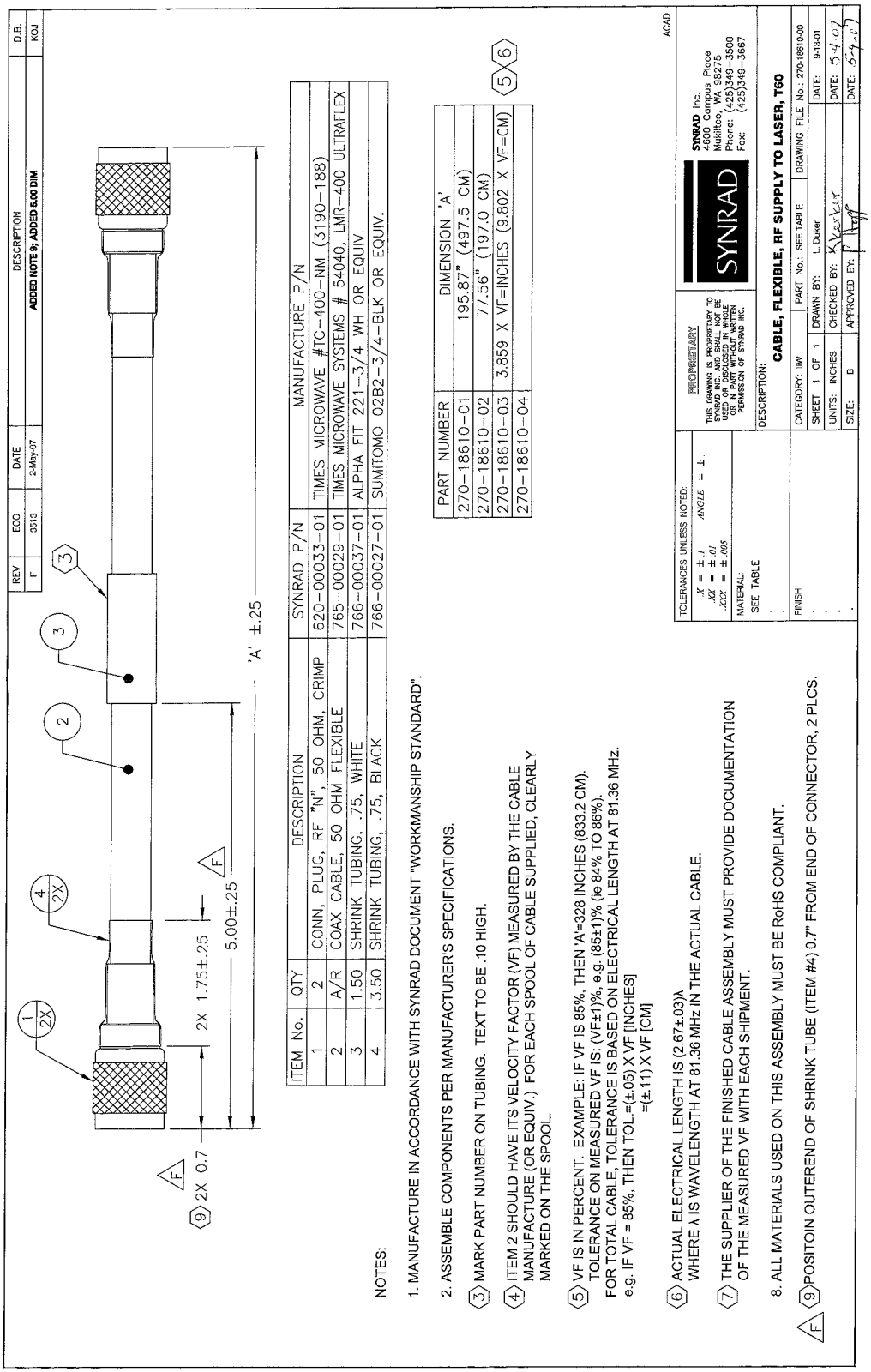

REV
ECO
DATE
DESCRIPTION
D.B.
F
3513
2-May-07
ADDED NOTE 9; ADDED 5.00 DIM
KOJ
1
2X
2
4
2X
3
3
5.00±.25
'A' ±.25
2X 1.75±.25
F
F
9 2X 0.7
ITEM No. | QTY | DESCRIPTION | SYNRAD P/N | MANUFACTURE P/N
1 | 2 | CONN, PLUG, RF "N", 50 OHM, CRIMP | 620-00033-01 | TIMES MICROWAVE #TC-400-NM (3190-188)
2 | A/R | COAX CABLE, 50 OHM FLEXIBLE | 765-00029-01 | TIMES MICROWAVE SYSTEMS # 54040, LMR-400 ULTRAFLEX
3 | 1.50 | SHRINK TUBING, .75, WHITE | 766-00037-01 | ALPHA FIT 221-3/4 WH OR EQUIV.
4 | 3.50 | SHRINK TUBING, .75, BLACK | 766-00027-01 | SUMITOMO 02B2-3/4-BLK OR EQUIV.
PART NUMBER | DIMENSION 'A'
270-18610-01 | 195.87" (497.5 CM)
270-18610-02 | 77.56" (197.0 CM)
270-18610-03 | 3.859 X VF=INCHES (9.802 X VF=CM)
270-18610-04
5 6
NOTES:
1. MANUFACTURE IN ACCORDANCE WITH SYNRAD DOCUMENT "WORKMANSHIP STANDARD".
2. ASSEMBLE COMPONENTS PER MANUFACTURER'S SPECIFICATIONS.
3 MARK PART NUMBER ON TUBING. TEXT TO BE .10 HIGH.
4 ITEM 2 SHOULD HAVE ITS VELOCITY FACTOR (VF) MEASURED BY THE CABLE MANUFACTURE (OR EQUIV.) FOR EACH SPOOL OF CABLE SUPPLIED, CLEARLY MARKED ON THE SPOOL.
5 VF IS IN PERCENT. EXAMPLE: IF VF IS 85%, THEN 'A'=328 INCHES (833.2 CM). TOLERANCE ON MEASURED VF IS: (VF±1)%, e.g. (85±1)% (ie 84% TO 86%). FOR TOTAL CABLE, TOLERANCE IS BASED ON ELECTRICAL LENGTH AT 81.36 MHz. e.g. IF VF = 85%, THEN TOL.=(±.05) X VF [INCHES] =(±.11) X VF [CM]
6 ACTUAL ELECTRICAL LENGTH IS (2.67±.03)λ WHERE λ IS WAVELENGTH AT 81.36 MHz IN THE ACTUAL CABLE.
7 THE SUPPLIER OF THE FINISHED CABLE ASSEMBLY MUST PROVIDE DOCUMENTATION OF THE MEASURED VF WITH EACH SHIPMENT.
8. ALL MATERIALS USED ON THIS ASSEMBLY MUST BE RoHS COMPLIANT.
F 9 POSITOIN OUTEREND OF SHRINK TUBE (ITEM #4) 0.7" FROM END OF CONNECTOR, 2 PLCS.
TOLERANCES UNLESS NOTED:
X = ± .1 ANGLE = ±
.XX = ± .01
.XXX = ± .005
MATERIAL:
SEE TABLE
FINISH:
PROPRIETARY
THIS DRAWING IS PROPRIETARY TO SYNRAD INC. AND SHALL NOT BE USED IN WHOLE OR IN PART WITHOUT WRITTEN PERMISSION OF SYNRAD INC.
SYNRAD
SYNRAD Inc.
4600 Campus Place
Mukilteo, WA 98275
Phone: (425)349-3500
Fax: (425)349-3667
ACAD
DESCRIPTION:
CABLE, FLEXIBLE, RF SUPPLY TO LASER, T60
CATEGORY: IIW
PART No.: SEE TABLE
DRAWING FILE No.: 270-18610-00
SHEET 1 OF 1
DRAWN BY: L. Dukes
DATE: 9-19-01
UNITS: INCHES
CHECKED BY:
DATE: 5-4-07
SIZE: B
APPROVED BY:
DATE: 5-4-07

Figure 3-28 t60/t80 RF cable dimensions

t-Series cable outline drawings

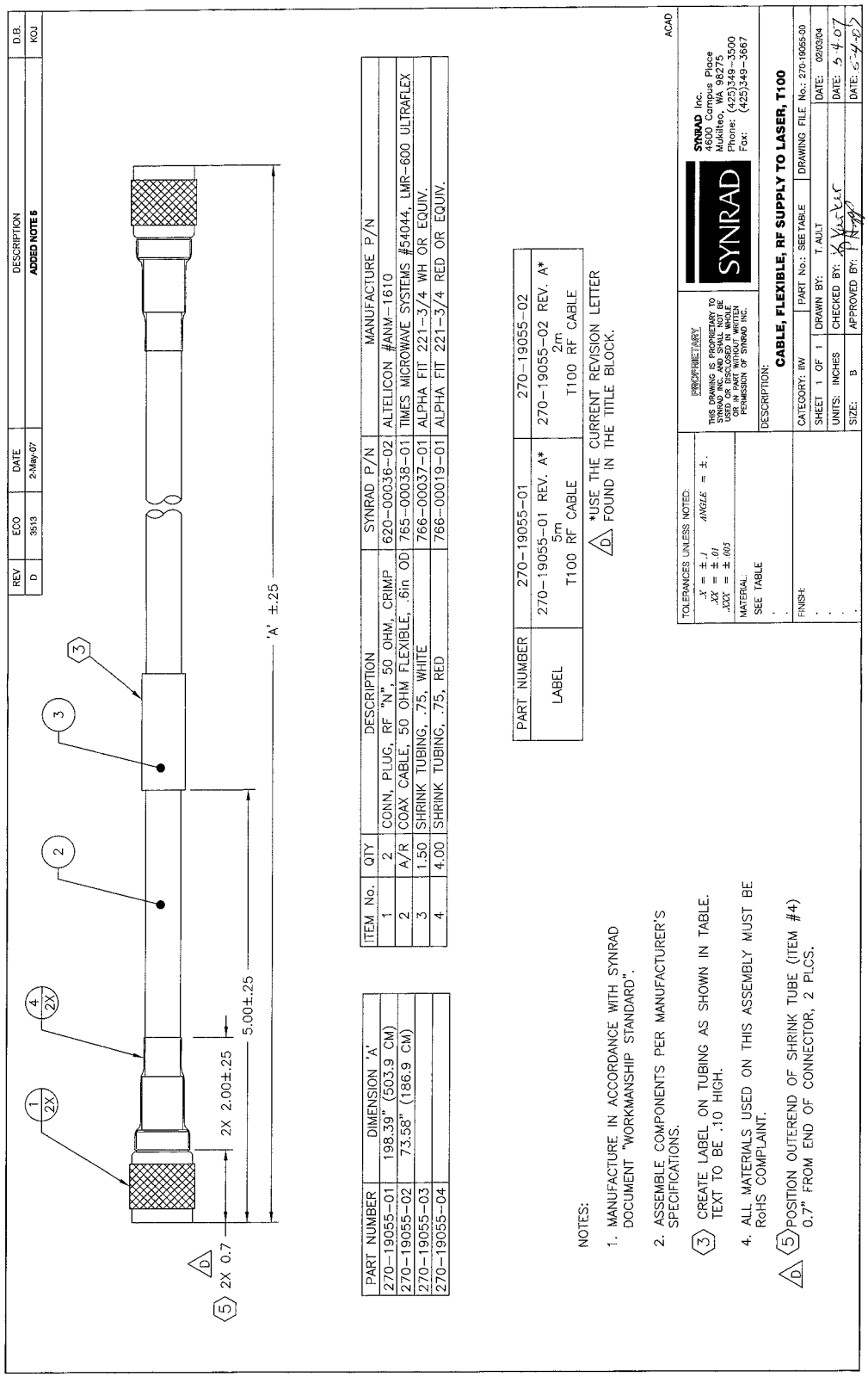

REV | ECO | DATE | DESCRIPTION | D.B.
D | 3513 | 2-May-07 | ADDED NOTE 6 | KOJ
'A' ±.25
5.00±.25
2X 2.00±.25
2X 0.7
PART NUMBER | DIMENSION 'A'
270-19055-01 | 198.39" (503.9 CM)
270-19055-02 | 73.58" (186.9 CM)
270-19055-03
270-19055-04
ITEM No. | QTY | DESCRIPTION | SYNRAD P/N | MANUFACTURE P/N
1 | 2 | CONN. PLUG, RF "N", 50 OHM, CRIMP | 620-00036-02 | ALTELICON #ANM-1610
2 | A/R | COAX CABLE, 50 OHM FLEXIBLE, .6in OD | 765-00038-01 | TIMES MICROWAVE SYSTEMS #54044, LMR-600 ULTRAFLEX
3 | 1.50 | SHRINK TUBING, .75, WHITE | 766-00037-01 | ALPHA FIT 221-3/4 WH OR EQUIV.
4 | 4.00 | SHRINK TUBING, .75, RED | 766-00019-01 | ALPHA FIT 221-3/4 RED OR EQUIV.
PART NUMBER | 270-19055-01 | 270-19055-02
LABEL | 270-19055-01 REV. A* 5m T100 RF CABLE | 270-19055-02 REV. A* 2m T100 RF CABLE
*USE THE CURRENT REVISION LETTER FOUND IN THE TITLE BLOCK.
NOTES:
1. MANUFACTURE IN ACCORDANCE WITH SYNRAD DOCUMENT "WORKMANSHIP STANDARD".
2. ASSEMBLE COMPONENTS PER MANUFACTURER'S SPECIFICATIONS.
3 CREATE LABEL ON TUBING AS SHOWN IN TABLE. TEXT TO BE .10 HIGH.
4. ALL MATERIALS USED ON THIS ASSEMBLY MUST BE RoHS COMPLAINT.
D 5 POSITION OUTEREND OF SHRINK TUBE (ITEM #4) 0.7" FROM END OF CONNECTOR, 2 PLCS.
TOLERANCES UNLESS NOTED:
X = ± .1 ANGLE = ±.
XX = ± .01
XXX = ± .005
MATERIAL:
SEE TABLE
FINISH:
PROPRIETARY
THIS DRAWING IS PROPRIETARY TO SYNRAD INC. AND SHALL NOT BE USED, REPRODUCED, IN WHOLE OR IN PART WITHOUT WRITTEN PERMISSION OF SYNRAD INC.
SYNRAD
SYNRAD Inc.
4600 Campus Place
Mukilteo, WA 98275
Phone: (425)349-3500
Fax: (425)349-3667
DESCRIPTION:
CABLE, FLEXIBLE, RF SUPPLY TO LASER, T100
CATEGORY: INV | PART No.: SEE TABLE | DRAWING FILE No.: 270-19055-00
SHEET 1 OF 1 | DRAWN BY: T. AULT | DATE: 02/03/04
UNITS: INCHES | CHECKED BY: | DATE: 5-4-07
SIZE: B | APPROVED BY: | DATE: 5-4-07
ACAD

Figure 3-29 t100 RF cable dimensions

t-Series cable outline drawings

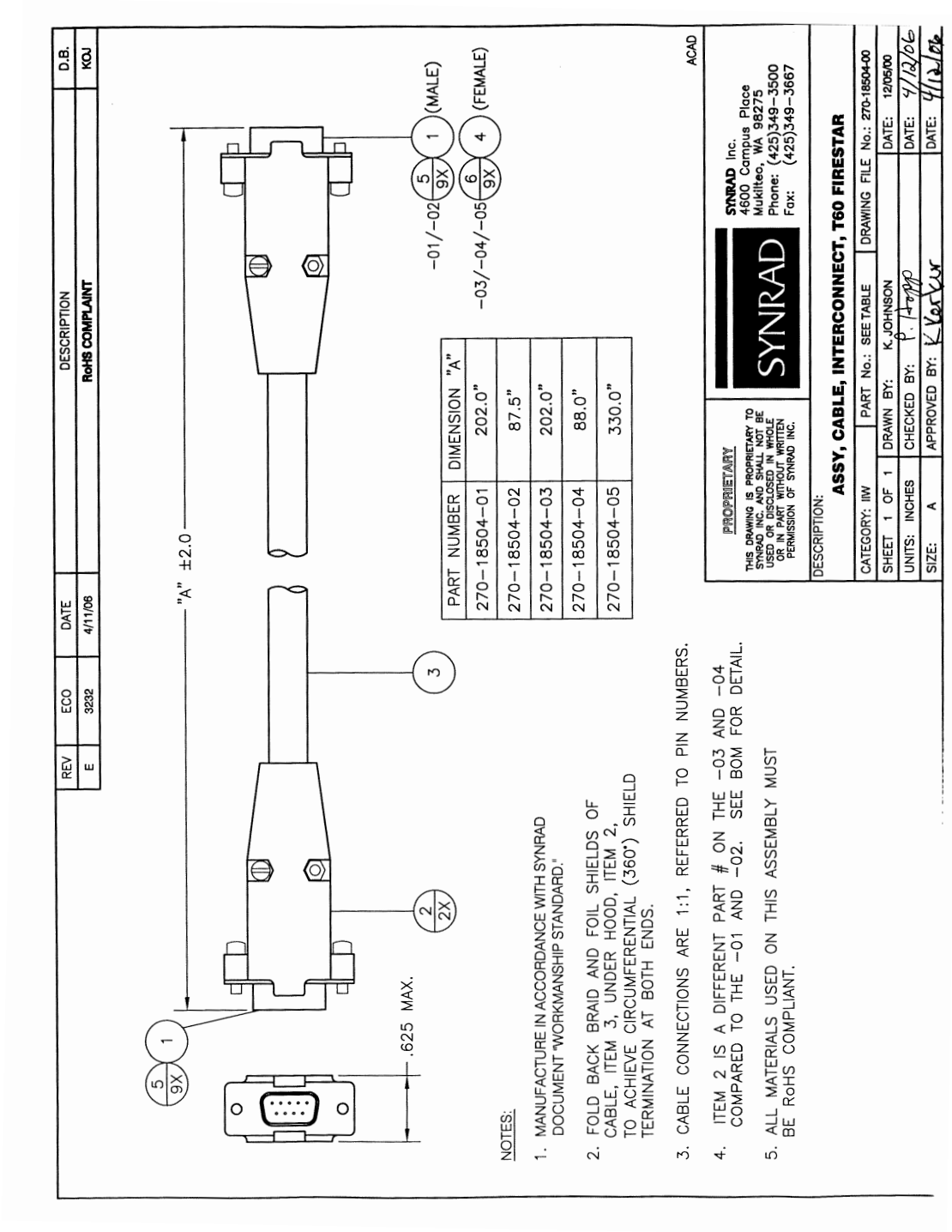


Figure 3-30 t-Series Interconnect cable dimensions

Packaging instructions

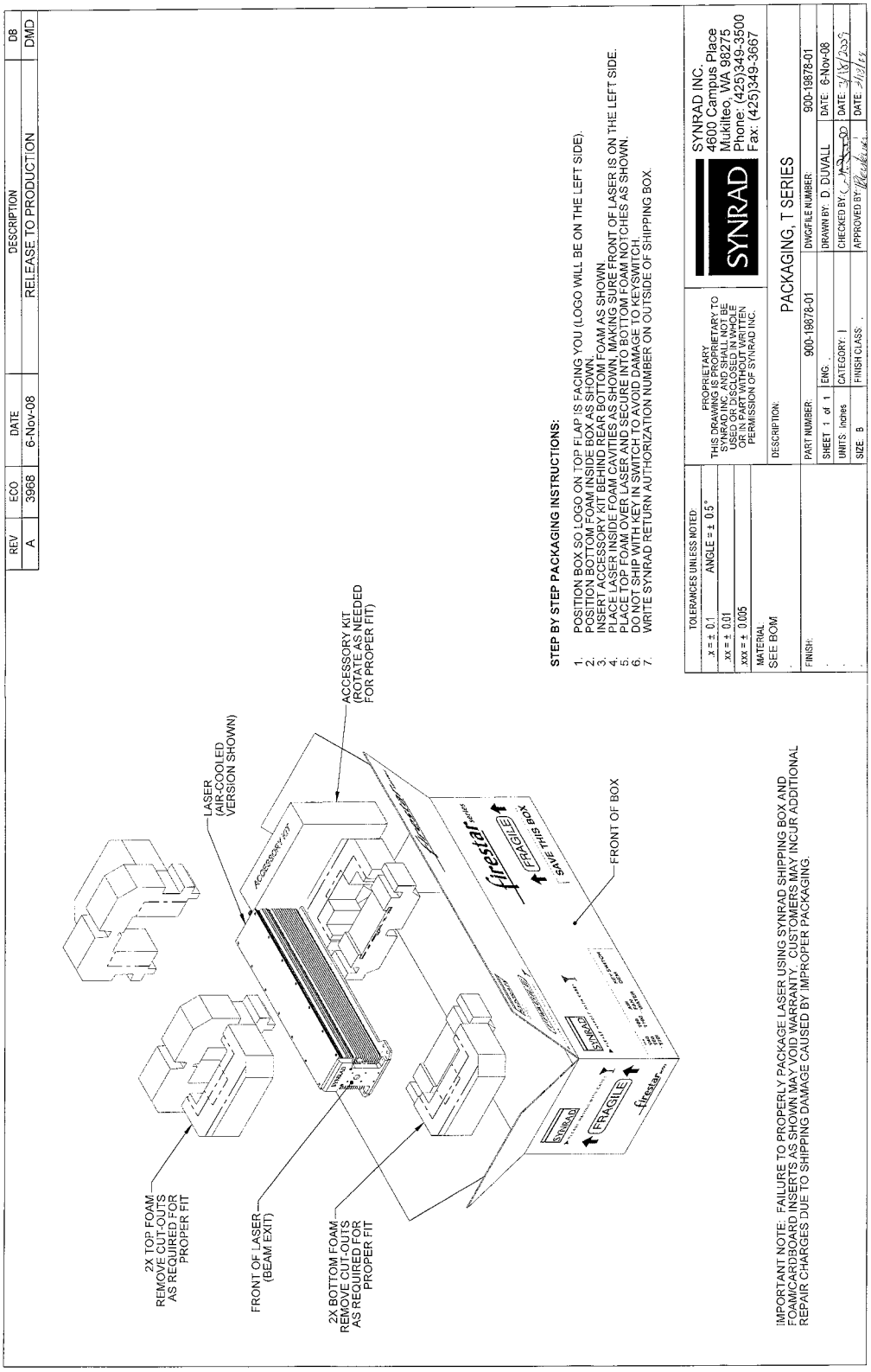

REV
ECO
DATE
DESCRIPTION
DB
A
3968
6-Nov-08
RELEASE TO PRODUCTION
DMD
STEP BY STEP PACKAGING INSTRUCTIONS:
1. POSITION BOX SO LOGO ON TOP FLAP IS FACING YOU (LOGO WILL BE ON THE LEFT SIDE).
2. POSITION BOTTOM FOAM INSIDE BOX AS SHOWN.
3. INSERT ACCESSORY KIT BEHIND REAR BOTTOM FOAM AS SHOWN.
4. PLACE LASER INSIDE FOAM CAVITIES AS SHOWN, MAKING SURE FRONT OF LASER IS ON THE LEFT SIDE.
5. PLACE TOP FOAM OVER LASER AND SECURE INTO BOTTOM FOAM NOTCHES AS SHOWN.
6. DO NOT SHIP WITH KEY IN SWITCH TO AVOID DAMAGE TO KEYSWITCH.
7. WRITE SYNRAD RETURN AUTHORIZATION NUMBER ON OUTSIDE OF SHIPPING BOX.
TOLERANCES UNLESS NOTED:
.X ± ± 0.1 ANGLE = ± 0.5°
.XX = ± 0.01
.XXX = ± 0.005
MATERIAL
SEE BOM
FINISH:
PROPRIETARY
THIS DRAWING IS PROPRIETARY TO SYNRAD INC. AND SHALL NOT BE USED OR DISCLOSED IN WHOLE OR IN PART WITHOUT WRITTEN PERMISSION OF SYNRAD INC.
SYNRAD
SYNRAD INC.
4600 Campus Place
Mukilteo, WA 98275
Phone: (425)349-3500
Fax: (425)349-3667
DESCRIPTION:
PACKAGING, T SERIES
PART NUMBER: 900-19678-01
SHEET 1 of 1
UNITS: inches
SIZE: B
ENG.
CATEGORY:
FINISH CLASS:
DWGFILE NUMBER: 900-19678-01
DRAWN BY: D. DUVALL
DATE: 6-Nov-08
CHECKED BY:
DATE:
APPROVED BY:
DATE:
IMPORTANT NOTE: FAILURE TO PROPERLY PACKAGE LASER USING SYNRAD SHIPPING BOX AND FOAM/CARDBOARD INSERTS AS SHOWN MAY VOID WARRANTY. CUSTOMERS MAY INCUR ADDITIONAL REPAIR CHARGES DUE TO SHIPPING DAMAGE CAUSED BY IMPROPER PACKAGING.
2X TOP FOAM REMOVE CUT-OUTS AS REQUIRED FOR PROPER FIT
FRONT OF LASER (BEAM EXIT)
2X BOTTOM FOAM REMOVE CUT-OUTS AS REQUIRED FOR PROPER FIT
LASER (AIR-COOLED VERSION SHOWN)
ACCESSORY KIT (ROTATE AS NEEDED FOR PROPER FIT)
FRONT OF BOX
ACCESSORY KIT
FRAGILE
THIS SIDE UP
Firestar

Figure 3-31 t-Series Laser Head packaging instructions

Packaging instructions

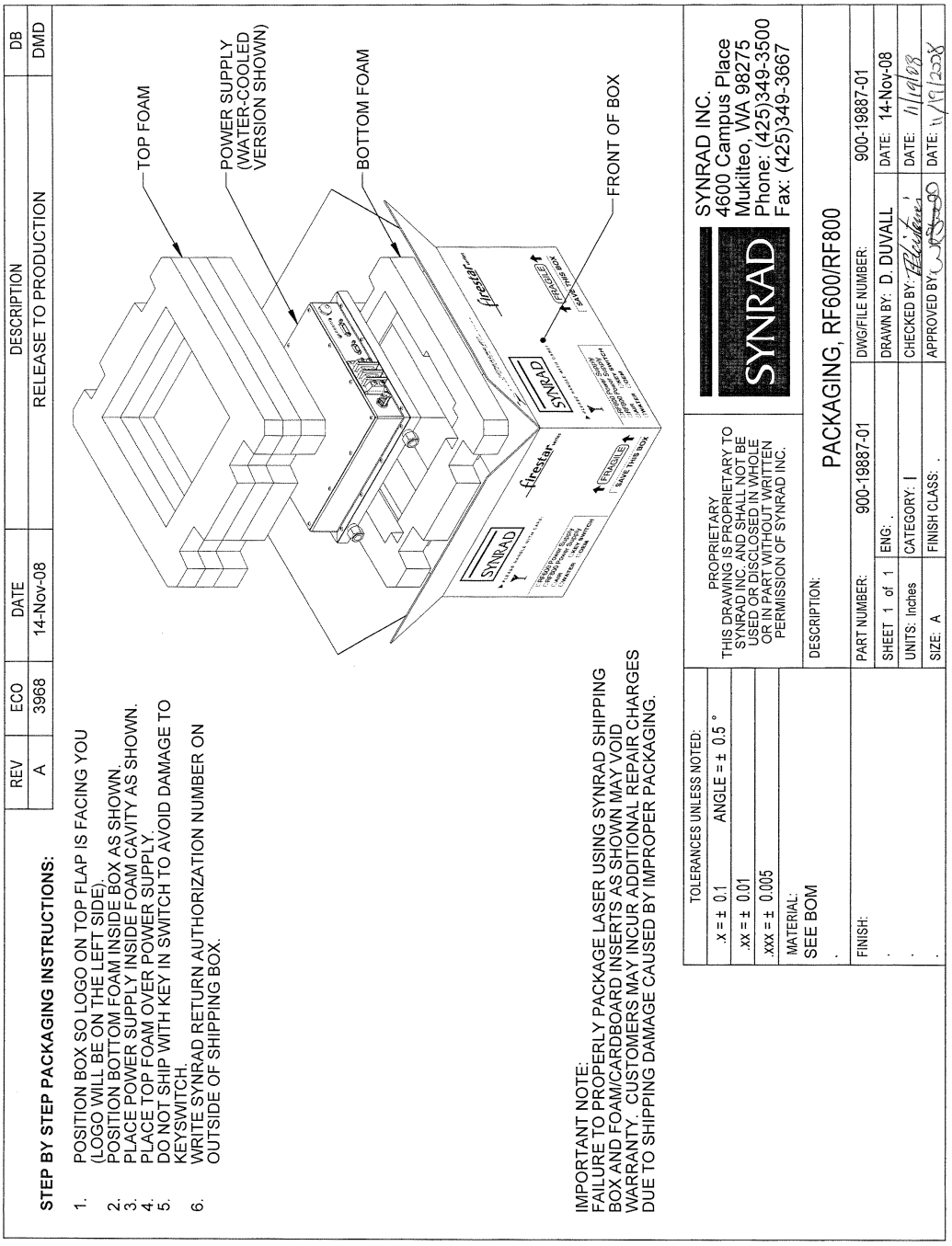
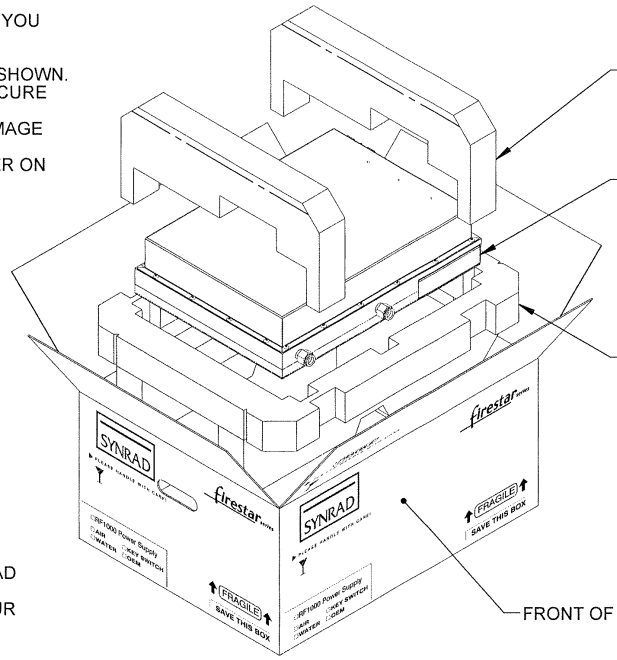

REV
ECO
DATE
DESCRIPTION
DB
A
3968
14-Nov-08
RELEASE TO PRODUCTION
DMD
STEP BY STEP PACKAGING INSTRUCTIONS:
1. POSITION BOX SO LOGO ON TOP FLAP IS FACING YOU (LOGO WILL BE ON THE LEFT SIDE).
2. POSITION BOTTOM FOAM INSIDE BOX AS SHOWN.
3. PLACE POWER SUPPLY INSIDE FOAM CAVITY AS SHOWN.
4. PLACE TOP FOAM OVER POWER SUPPLY.
5. DO NOT SHIP WITH KEY IN SWITCH TO AVOID DAMAGE TO KEYSWITCH.
6. WRITE SYNRAD RETURN AUTHORIZATION NUMBER ON OUTSIDE OF SHIPPING BOX.
IMPORTANT NOTE:
FAILURE TO PROPERLY PACKAGE LASER USING SYNRAD SHIPPING BOX AND FOAM/CARDBOARD INSERTS AS SHOWN MAY VOID WARRANTY. CUSTOMERS MAY INCUR ADDITIONAL REPAIR CHARGES DUE TO SHIPPING DAMAGE CAUSED BY IMPROPER PACKAGING.
TOP FOAM
POWER SUPPLY (WATER-COOLED VERSION SHOWN)
BOTTOM FOAM
FRONT OF BOX
TOLERANCES UNLESS NOTED:
.x = ± 0.1 ANGLE = ± 0.5 °
.xx = ± 0.01
.xxx = ± 0.005
MATERIAL:
SEE BOM
FINISH:
PROPRIETARY
THIS DRAWING IS PROPRIETARY TO SYNRAD INC. AND SHALL NOT BE USED OR DISCLOSED IN WHOLE OR IN PART WITHOUT WRITTEN PERMISSION OF SYNRAD INC.
DESCRIPTION:
PACKAGING, RF600/RF800
PART NUMBER: 900-19887-01
SHEET 1 of 1
UNITS: Inches
SIZE: A
DWG/FILE NUMBER: 900-19887-01
DRAWN BY: D. DUVALL
ENG: .
CATEGORY: I
FINISH CLASS: .
CHECKED BY:
APPROVED BY:
DATE: 14-Nov-08
DATE: 11/19/08
DATE: 11/19/2008
SYNRAD
SYNRAD INC.
4600 Campus Place
Mukilteo, WA 98275
Phone: (425)349-3500
Fax: (425)349-3667

Figure 3-32 RF-600/RF-800 packaging instructions

REV	ECO	DATE	DESCRIPTION	DB
A	3968	14-Nov-08	RELEASE TO PRODUCTION	DMD

STEP BY STEP PACKAGING INSTRUCTIONS:

1. POSITION BOX SO LOGO ON TOP FLAP IS FACING YOU (LOGO WILL BE ON THE LEFT SIDE).
2. POSITION BOTTOM FOAM INSIDE BOX AS SHOWN.
3. PLACE POWER SUPPLY INSIDE FOAM CAVITY AS SHOWN.
4. PLACE TOP FOAM OVER POWER SUPPLY AND SECURE INTO BOTTOM FOAM NOTCHES AS SHOWN.
5. DO NOT SHIP WITH KEY IN SWITCH TO AVOID DAMAGE TO KEYSWITCH.
6. WRITE SYNRAD RETURN AUTHORIZATION NUMBER ON OUTSIDE OF SHIPPING BOX.


2X TOP FOAM REMOVE CUT-OUTS AS REQUIRED FOR PROPER FIT
POWER SUPPLY (WATER-COOLED VERSION SHOWN)
BOTTOM FOAM REMOVE CUT-OUTS AS REQUIRED FOR PROPER FIT
FRONT OF BOX
SYNRAD
firestar
FRAGILE
SAVE THIS BOX

IMPORTANT NOTE:
FAILURE TO PROPERLY PACKAGE LASER USING SYNRAD SHIPPING BOX AND FOAM/CARDBOARD INSERTS AS SHOWN MAY VOID WARRANTY. CUSTOMERS MAY INCUR ADDITIONAL REPAIR CHARGES DUE TO SHIPPING DAMAGE CAUSED BY IMPROPER PACKAGING.

TOLERANCES UNLESS NOTED:		PROPRIETARY THIS DRAWING IS PROPRIETARY TO SYNRAD INC. AND SHALL NOT BE USED OR DISCLOSED IN WHOLE OR IN PART WITHOUT WRITTEN PERMISSION OF SYNRAD INC.	SYNRAD INC. 4600 Campus Place Mukilteo, WA 98275 Phone: (425)349-3500 Fax: (425)349-3667	
.x = ± 0.1	ANGLE = ± 0.5 °			
.xx = ± 0.01				
.xxx = ± 0.005				
MATERIAL: SEE BOM .		DESCRIPTION: PACKAGING, RF1000		
FINISH: . . .		PART NUMBER: 900-19888-01	DWG/FILE NUMBER: 900-19888-01	
		SHEET 1 of 1 / ENG: .	DRAWN BY: D. DUVALL	DATE: 14-Nov-08
		UNITS: Inches / CATEGORY:	CHECKED BY:	DATE: 11/19/08
		SIZE: A / FINISH CLASS: .	APPROVED BY:	DATE: 11/19/2008

Figure 3-33 RF-1000 packaging instructions

4 maintenance/ troubleshooting

Use information in this section to perform maintenance or troubleshoot your Firestar t-Series laser.

This section contains the following information:

- Maintenance – describes typical t-Series maintenance procedures.
- Troubleshooting – explains how to troubleshoot common t-Series problems.

maintenance/ troubleshooting

Maintenance

The *Maintenance* section includes subsections:

- Disabling Firestar
- Daily inspections
- Storage/shipping
- Cleaning optical components

Disabling Firestar

Before performing any maintenance on your Firestar® t-Series laser, be sure to completely disable the laser by disconnecting DC power from the rear panel of the RF power supply.

Daily inspections

Perform the following steps daily to keep your Firestar t-Series laser in optimum operating condition. Except for the procedures described below, no other service is required or should be attempted.

Caution possible equipment damage	If you operate your laser or marking head in a dirty or dusty environment, contact SYNRAD about the risks of doing so and precautions you can take to increase the longevity of your laser, marking head, and associated optical components.

1. For water-cooled lasers, inspect cooling tubing connections for signs of leakage. Check for signs of condensation that may indicate the cooling water temperature is set below the dew point temperature. Condensation will damage electrical and optical components inside the laser and RF power supply. See *Setting coolant temperature* in the Getting Started chapter for details on preventing condensation.
2. Inspect beam delivery components for signs of dust or debris and clean as required. When cleaning the optical surfaces of beam delivery components, carefully follow the manufacturer's instructions.

⚠ Warning serious personal injury	A risk of exposure to toxic elements, like zinc selenide, may result when certain optical or beam delivery components are damaged. In the event of damage to laser, marking head, or beam delivery optics, contact SYNRAD, Inc. or the optics manufacturer for handling instructions.

maintenance/ troubleshooting

Maintenance

3 Visually inspect the exterior housing of the Laser Head and RF power supply to ensure that all warning labels are present. Refer to *t-Series label locations* and *RF power supply label locations* in the Laser Safety chapter for label types and locations.

Storage/shipping

When preparing a water-cooled laser for storage or shipping, remember to drain cooling water from the Laser Head and the RF power supply. In cold climates, any water left in the cooling system may freeze, which could damage internal components. After draining thoroughly, use compressed shop air at no more than 29 PSI (while wearing safety glasses!) to remove any residual water. When finished, cap all cooling connectors to prevent debris from entering the cooling system.

When shipping SYNRAD lasers to another facility, we highly recommend that you ship the unit in its original SYNRAD shipping container. If you no longer have the original shipping box and inserts, contact SYNRAD Customer Service about purchasing replacement packaging. Refer to *Packaging instructions* in the Technical Reference chapter for detailed instructions on properly packaging the laser for shipment.

Important Note: Failure to properly package the laser and RF power supply using SYNRAD-supplied shipping boxes and foam/cardboard inserts as shown in the Packaging Instructions may void the warranty. Customers may incur additional repair charges for shipping damage caused by improper packaging.

Cleaning optical components

⚠ **Danger** serious personal injury	Ensure that DC power to the laser is turned off and locked out before inspecting optical components in the beam path. ***Invisible*** CO_2 laser radiation is emitted through the aperture. Corneal damage or blindness may result from exposure to laser radiation.

Caution possible equipment damage	Because of their smaller beam diameter, Firestar lasers have significantly higher power densities than previous SYNRAD lasers. This means that even a small amount of contamination on the laser's output window (or on any optic in the beam path) can absorb enough energy to damage the optic. Inspect the output window and other beam delivery optics periodically for signs of contaminants and carefully clean as required. In dirty environments, purge laser optics using filtered air or nitrogen to prevent vapor and debris from accumulating on optical surfaces.

maintenance/ troubleshooting

Maintenance

Debris or contaminants on the laser's output coupler or external beam delivery components may affect laser processing and lead to damage or failure of the optics and/or the laser. Carefully follow the steps below to inspect and clean the optical components in the beam path. Before beginning the cleaning process, read this entire section thoroughly to ensure that all cleaning materials are available and that each step is completely understood.

Important Note: Exercise great care when handling infrared optics; they are much more fragile than common glass materials. Optical surfaces and coatings are easily damaged by rough handling and improper cleaning methods.

Cleaning guidelines

- Wear rubber or latex finger cots or rubber gloves (powder-free) to prevent contamination of optical surfaces by dirt and skin oils.
- Never handle optics with tools; always use gloved hands or fingers.
- Hold optics by the outer edge; never touch the coated surface.
- Always place optics on lens tissue for protection; never place optics on hard or rough surfaces.
- It may be necessary to use a fluffed cotton swab or cotton ball instead of a lens wipe to uniformly clean the entire surface of small-diameter mounted optics.
- Before using cleaning agents, read Material Safety Data Sheets (MSDS) and observe all necessary safety precautions.

Required cleaning materials

Table 4-1 lists the type and grade of materials required to properly clean optical surfaces.

Table 4-1 Required cleaning materials

Cleaning Material	Requirements
Finger cots or rubber gloves	Powder free
Air bulb	Clean air bulb
Ethyl alcohol	Spectroscopic or reagent grade
Acetone	Spectroscopic or reagent grade
Lens wipe (preferred)	Optical (cleanroom) quality
Cotton balls or cotton swabs	High-quality surgical cotton/high-quality paper-bodied

maintenance/ troubleshooting

Maintenance

Cleaning optics

1 Shut off and lock out all power to the laser. You must verify that the laser is OFF (in a zero-energy state) before continuing with the optical inspection!

2 Visually inspect all optical surfaces in the beam path, including the laser's output coupler, for contaminants.

Caution possible lens damage	Do not allow the nozzle of the air bulb to touch the optical surface. Any contact may damage the optic by scratching coatings on the optical surface. Do not use compressed shop air to blow contamination from the optic. Compressed air contains significant amounts of water and oil that form adsorbing films on the optical surface. Do not exert pressure on the surface of the optic during cleaning. Optical surfaces and coatings are easily scratched by dislodged contaminants. Use a new lens wipe on each pass as contaminants picked up by the wipe may scratch the optical surface.

3 Remove loose contaminants from the optic by holding a clean air bulb at an angle to the optic and blow a stream of air at a glancing angle across the lens surface. Repeat as necessary.

4 Dampen a lens wipe with the selected cleaning agent. Ethyl alcohol (least aggressive) is best for initial surface cleaning. Acetone (moderately aggressive) is best for oily residue or minor baked-on vapors and debris.

Important Note: If acetone is used as a cleaning solvent, a second follow-up cleaning of the optical surface using ethyl alcohol is required to remove any acetone residue.

5 Gently, and without applying pressure, drag the damp lens wipe across the optical surface in a single pass. **Do not rub or apply any pressure**, especially when using a cotton swab. Drag the wipe without applying any downward pressure.

Note: Use a clean lens wipe on each pass. The wipe will pick up and carry surface contaminants that may scratch optical surfaces or coatings.

To prevent streaking during the final ethyl alcohol cleaning, drag the lens wipe slowly across the surface so that the cleaning liquid evaporates right behind the wipe.

6 Carefully examine the optic under a good light. Certain contaminants or damage such as pitting cannot be removed. In these cases the optic must be replaced to prevent catastrophic failure.

7 Repeat Steps 4 through 6 as required, removing all traces of contaminants and deposits.

maintenance/ troubleshooting

Troubleshooting

The *Troubleshooting* section includes subsections:

- Introduction
- Operational flowchart
- Functional block diagram
- Status LEDs
- Laser faults
- Resetting faults
- Other laser faults
- Laser replacement
- Beam delivery optics

Introduction

This section is designed to help isolate problems to the module level only. Problems on circuit boards or the laser tube are outside the scope of this guide because they are not user-serviceable assemblies; do not attempt to repair them. Contact SYNRAD or a SYNRAD Authorized Distributor for repair/replacement information. To troubleshoot the Firestar t-Series laser, it is necessary to understand the sequence of events that must happen before the laser can turn on and operate. Before you attempt to perform any service, we advise you to read the entire troubleshooting guide and review both the operational flowchart and the functional block diagram. Symptoms and possible causes are highlighted by dark print and bullet points throughout this section. Information about each symptom and cause can be found in paragraphs following each heading.

⚠ Danger serious personal injury	This Class IV laser product emits ***invisible*** infrared laser radiation at the 10.6 µm CO_2 wavelength. Direct or diffuse laser radiation can inflict severe corneal injuries and can seriously burn human or animal tissue. Service personnel troubleshooting Firestar lasers should be thoroughly trained in laser safety practices and electronic service techniques before attempting repairs.

Caution possible equipment damage	Attempting repair of a SYNRAD Firestar laser without the express authorization of SYNRAD, Inc. will void the product warranty. If troubleshooting or service assistance is required, please contact SYNRAD Customer Service.

Troubleshooting

Operational flowchart

The flowchart in Figure 4-1 illustrates Firestar's start-up sequence.

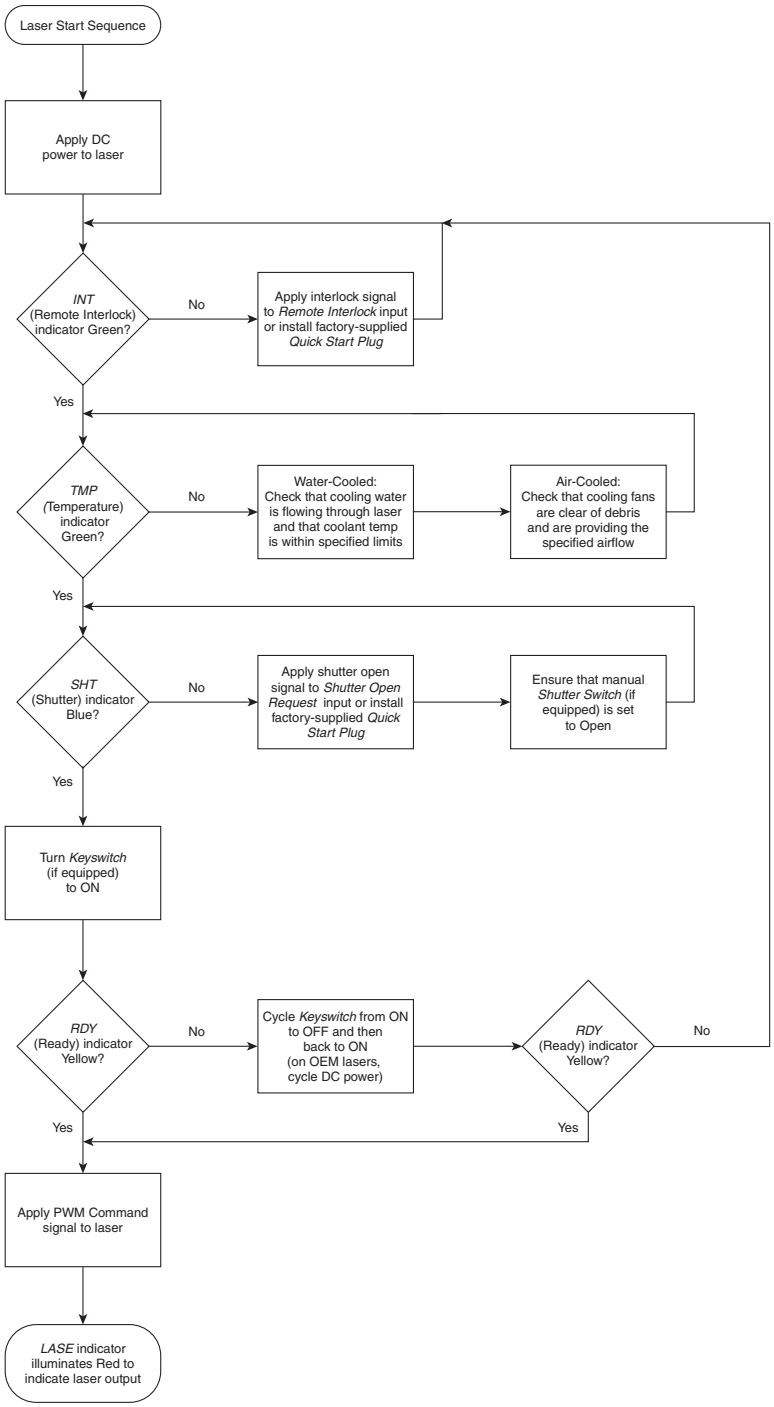

Laser Start Sequence
Apply DC power to laser
INT (Remote Interlock) indicator Green?
No
Apply interlock signal to Remote Interlock input or install factory-supplied Quick Start Plug
Yes
TMP (Temperature) indicator Green?
No
Water-Cooled: Check that cooling water is flowing through laser and that coolant temp is within specified limits
Air-Cooled: Check that cooling fans are clear of debris and are providing the specified airflow
Yes
SHT (Shutter) indicator Blue?
No
Apply shutter open signal to Shutter Open Request input or install factory-supplied Quick Start Plug
Ensure that manual Shutter Switch (if equipped) is set to Open
Yes
Turn Keyswitch (if equipped) to ON
RDY (Ready) indicator Yellow?
No
Cycle Keyswitch from ON to OFF and then back to ON (on OEM lasers, cycle DC power)
RDY (Ready) indicator Yellow?
No
Yes
Yes
Apply PWM Command signal to laser
LASE indicator illuminates Red to indicate laser output

Figure 4-1 Operational flowchart

maintenance/ troubleshooting

Troubleshooting

Functional block diagram

Figure 4-2 is a functional block diagram illustrating t-Series control architecture.

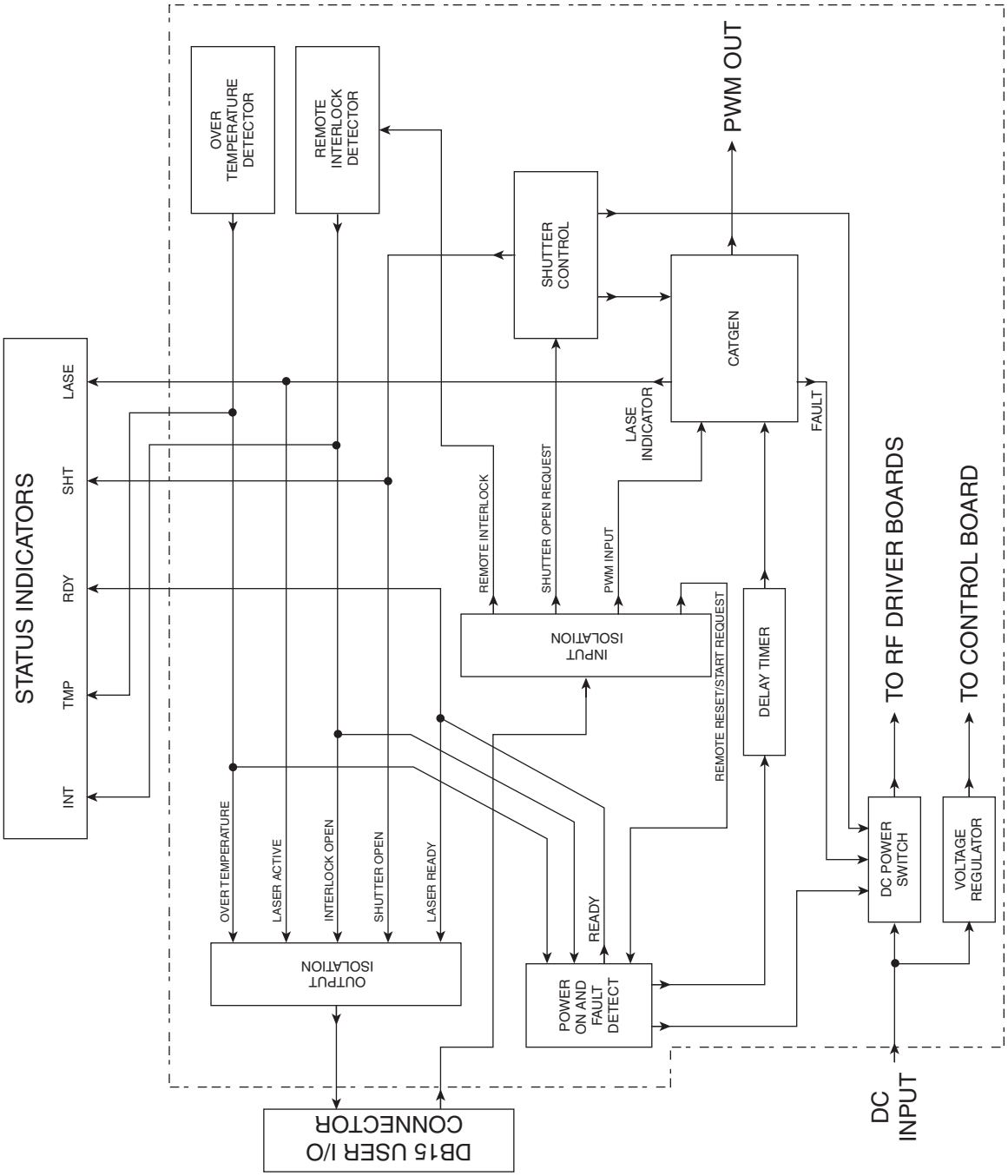


Figure 4-2 t-Series functional block diagram

maintenance/ troubleshooting

Status LEDs

Firestar t-Series LED indicators, also mirrored as output signals on the *User I/O* connector, provide status information to the user. Table 4-2 shows Firestar output signal and LED indicator states during normal and fault conditions. *User I/O* outputs are Closed when the state indicated by the signal name is True.

Table 4-2 Status signals

LED Indicator	LED Status		Signal Name	User I/O Output Status	
	Normal	Fault		Normal	Fault
INT	Green	Red	Interlock Open	Open	Closed
TMP	Green	Red	Over Temperature	Open	Closed
RDY	Yellow	Off	Laser Ready	Closed	Open
SHT	Blue	Off	Shutter Open	Closed	Open
LASE	Red	Off	Laser Active	Closed	Open

On t-Series keyswitch lasers, the *RDY* indicator illuminates yellow only when *INT* and *TMP* indicators are green and the *Keyswitch* is cycled from OFF to the ON position. After the *RDY* indicator illuminates, a five-second delay occurs before Firestar is permitted to lase. The *SHT* LED illuminates blue when a Shutter Open Request signal is applied and the manual *Shutter Switch* is set to Open. If the *RDY* indicator is lit and the shutter is switched from Closed to Open, there is a five-second delay until PWM inputs are recognized. When PWM Command pulses are applied (and are long enough to produce laser output) the *LASE* LED illuminates red.

On OEM lasers, the *RDY* lamp illuminates on DC power-up when *INT* and *TMP* indicators illuminate green. After the *RDY* indicator illuminates, a five-second delay occurs before Firestar is permitted to lase. The *SHT* LED illuminates blue when a Shutter Open Request signal is applied. If the *RDY* indicator is lit and then a Shutter Open Request signal is applied, there is a five-second delay until PWM inputs are recognized. When PWM Command pulses are applied (and are long enough to produce laser output) the *LASE* LED illuminates red.

Note: Firestar *RDY* and *SHT* indicators (as well as Laser Ready and Shutter Open outputs) denote separate control functions. Although the *RDY* lamp may light while the *SHT* LED is Off (*Shutter Switch* Closed or Shutter Open Request signal missing), no power is applied to the RF boards until both *RDY* and *SHT* indicators are illuminated.

Tables 4-3 through 4-5 on the following page show how Firestar's signal status changes when remote interlock, over temperature, or shutter closed conditions occur.

Troubleshooting

Table 4-3 Interlock Open condition

LED Indicator	LED Status	Signal Name	Output Signal Status
INT	Red	Interlock Open	Closed
TMP	Green	Over Temperature	Open
RDY	Off	Laser Ready	Open
SHT	Blue	Shutter Open	Closed
LASE	Off	Laser Active	Open

Table 4-4 Over Temperature condition

LED Indicator	LED Status	Signal Name	Output Signal Status
INT	Green	Interlock Open	Open
TMP	Red	Over Temperature	Closed
RDY	Off	Laser Ready	Open
SHT	Blue	Shutter Open	Closed
LASE	Off	Laser Active	Open

Table 4-5 Shutter Open condition

LED Indicator	LED Status	Signal Name	Output Signal Status
INT	Green	Interlock Open	Open
TMP	Green	Over Temperature	Open
RDY	Yellow	Laser Ready	Closed
SHT	Off	Shutter Open	Open
LASE	Off	Laser Active	Open

maintenance/ troubleshooting

Laser faults

Firestar t-Series lasers version C and above (KFC, SAC, etc.) have the ability to indicate five specific fault conditions. In the event of a certain faults, *RDY* LEDs on the RF power supply and Laser Head blink an error code, pause four seconds, and then repeat the error code. This sequence continues until the fault is corrected and the laser is reset by cycling DC power to the RF power supply.

Table 4-6 lists error codes, the corresponding fault condition, and describes any corrective action possible in the field.

Table 4-6 Laser faults

Number of Blinks Ready (RDY) Indicator	Fault Condition	Corrective Action in Field
1 blink	Under Voltage Fault	Verify the correct DC voltage is measured at the RF supply under load
2 blinks	Over Voltage Fault	Verify the correct DC voltage is measured at the RF supply under load
3 blinks	RF Drive DC Fault	None
4 blinks	PWM Drive Fault	None
5 blinks	RF Cable Interlock Fault	Check length of RF cable for damage or check for loose connections at Laser Head or RF power supply

Resetting faults

Keyswitch lasers

Remote interlock fault

A remote interlock fault occurs when the Remote Interlock input opens (the *INT* indicator changes from green to red). To reset a remote interlock fault, re-establish the Remote Interlock signal input (*INT* indicator changes from red to green) and cycle the *Keyswitch* from OFF to ON (or apply a Remote Reset/Start Request pulse with the *Keyswitch* set to ON). When the *RDY* indicator illuminates, lasing is enabled after a five-second delay.

Over temperature fault

Over temperature faults occur when thermal limits in the Laser Head or RF power supply are exceeded (the *TMP* indicator changes from green to red). To reset an over temperature fault, lower coolant temperature below 22 °C (water-cooled) or below 40 °C (air-cooled), cycle DC power to the RF power supply, and then cycle the *Keyswitch* from OFF to ON (or apply a Remote Reset/Start Request pulse with the *Keyswitch* set to ON). When the *RDY* indicator illuminates, lasing is enabled after a five-second delay.

maintenance/ troubleshooting

Troubleshooting

Shutter

A closed shutter is not considered a fault condition. When a Shutter Open Request signal is applied, lasing is enabled after a five-second delay provided that the *RDY* indicator is illuminated yellow.

Under/over voltage fault

An under voltage or over voltage fault occurs when the DC input voltage is below or above preset limits. This fault is indicated by the RDY indicator flashing 1 blink (under voltage) or 2 blinks (over voltage). To reset an under voltage or over voltage fault, ensure that 30 VDC (t60/t100) or 36 VDC (t80) is applied to the RF power supply under full-load conditions, cycle DC power, and then toggle the *Keyswitch* from OFF to ON (or apply a Remote Reset/Start Request pulse with the *Keyswitch* set to ON). When the *RDY* indicator illuminates, lasing is enabled after a five-second delay.

RF Drive DC fault

An RF Drive DC fault is indicated by the RDY indicator flashing 3 blinks. Reset the laser by removing DC power to the RF power supply, wait 30 seconds, reapply DC power, and then toggle the *Keyswitch* from OFF to ON (or apply a Remote Reset/Start Request pulse with the *Keyswitch* set to ON). If the RF Drive DC fault reappears, contact SYNRAD or a SYNRAD Authorized Distributor.

PWM Drive fault

A PWM Drive fault is indicated by the RDY indicator flashing 4 blinks. Reset the laser by removing DC power to the RF power supply, wait 30 seconds, reapply DC power, and then toggle the *Keyswitch* from OFF to ON (or apply a Remote Reset/Start Request pulse with the *Keyswitch* set to ON). If the PWM Drive fault reappears, contact SYNRAD or a SYNRAD Authorized Distributor.

RF Cable Interlock fault

An RF Cable Interlock fault occurs when the RF cable loses continuity (appears electrically open). This fault is indicated by the RDY indicator flashing 5 blinks. Verify that the RF cable is undamaged and that connectors on both the Laser Head and RF power supply are tight. To reset an RF Cable Interlock fault, cycle DC power, and then toggle the *Keyswitch* from OFF to ON (or apply a Remote Reset/Start Request pulse with the *Keyswitch* set to ON). When the *RDY* indicator illuminates, lasing is enabled after a five-second delay.

maintenance/ troubleshooting

Troubleshooting

OEM lasers

⚠ Warning
serious personal injury

On Firestar t-Series OEM lasers, remote interlock (*INT*) faults are not latched. Clearing the fault condition re-enables the *RDY* indicator and the laser will fire after the five-second delay provided that the *SHT* indicator is lit and a PWM Command signal is applied. Because exposure to 10.6 µm CO_2 laser radiation can inflict severe corneal injuries and seriously burn human tissue, the OEM or System Integrator must ensure that appropriate safeguards are in place to prevent unintended lasing.

Remote interlock fault

A remote interlock fault occurs when the Remote Interlock input opens (the *INT* indicator changes from green to red). On OEM lasers, remote interlock (*INT*) faults are not latched. Re-establish the Remote Interlock signal input (*INT* indicator changes from red to green) to enable the *RDY* indicator and begin lasing after the five-second delay.

Over temperature fault

Over temperature faults occur when thermal limits in the Laser Head or RF power supply are exceeded (the *TMP* indicator changes from green to red). Beginning with OEM C version lasers, over temperature faults are now latched. To reset an over temperature fault, lower coolant temperature below 22 °C (water-cooled) or below 40 °C (air-cooled) and then cycle DC power to the RF power supply. Once the *RDY* lamp is lit, lasing is possible after the five-second delay.

Note: Over temperature faults are not latched on B version OEM lasers. Cool the laser until the *TMP* indicator changes from red to green. After the *RDY* lamp lights, lasing is possible after the five-second delay.

Shutter

A closed shutter is not considered a fault condition. When a Shutter Open Request signal is applied, lasing is enabled after a five-second delay provided that the *RDY* indicator is illuminated yellow.

Under/over voltage fault

An under voltage or over voltage fault occurs when the DC input voltage is below or above preset limits. This fault is indicated by the RDY indicator flashing 1 blink (under voltage) or 2 blinks (over voltage). To reset an under voltage or over voltage fault, ensure that 30 VDC (t60/t100) or 36 VDC (t80) is applied to the RF power supply under full-load conditions and then cycle DC power. When the *RDY* indicator illuminates, lasing is enabled after a five-second delay.

maintenance/ troubleshooting

Troubleshooting

RF Drive DC fault

An RF Drive DC fault is indicated by the RDY indicator flashing 3 blinks. Reset the laser by removing DC power to the RF power supply, wait 30 seconds, and then reapply DC power. If the RF Drive DC fault reappears, contact SYNRAD or a SYNRAD Authorized Distributor.

PWM Drive fault

A PWM Drive fault is indicated by the RDY indicator flashing 4 blinks. Reset the laser by removing DC power to the RF power supply, wait 30 seconds, and then reapply DC power. If the PWM Drive fault reappears, contact SYNRAD or a SYNRAD Authorized Distributor.

RF Cable Interlock fault

An RF Cable Interlock fault occurs when the RF cable loses continuity (appears electrically open). This fault is indicated by the RDY indicator flashing 5 blinks. Verify that the RF cable is undamaged and that connectors on both the Laser Head and RF power supply are tight. To reset an RF Cable Interlock fault, cycle DC power. When the *RDY* indicator illuminates, lasing is enabled after a five-second delay.

Other laser faults

When a laser fault occurs, Firestar's status LEDs and output signals will reflect a fault condition as indicated in Tables 4-3–4-5 or Table 4-6 . Each Symptom listed below describes a particular fault. For each Symptom, specific causes and solutions are described under Possible Causes.

⚠ Warning
serious personal injury

On Firestar t-Series OEM lasers, remote interlock (*INT*) faults are not latched. Clearing the fault condition re-enables the *RDY* indicator and the laser will fire after the five-second delay provided that the *SHT* indicator is lit and a PWM Command signal is applied. Because exposure to 10.6 µm CO_2 laser radiation can inflict severe corneal injuries and seriously burn human tissue, the OEM or System Integrator must ensure that appropriate safeguards are in place to prevent unintended lasing.

Symptom:

- A remote interlock fault is indicated:

INT LED	– Red	Interlock Open	– Closed
TMP LED	– Green	Over Temperature	– Open
RDY LED	– Off	Laser Ready	– Open
SHT LED	– Blue	Shutter Open	– Closed
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- No voltage applied to Pin 3 (Remote Interlock) of the *User I/O* connector.

maintenance/ troubleshooting

Troubleshooting

On systems using remote interlocks, check to see that a positive or negative voltage (±5–24 VDC) is applied to Pin 3, Remote Interlock, with respect to Pin 11, Input Common, on the *User I/O* connector (refer to *User I/O connections* in the Technical Reference chapter for details). For systems not using interlocks, connect the factory-supplied *Quick Start Plug* to the *User I/O* connector on the RF supply's rear panel or wire your male DB-15 connector so that Pin 11 (Input Common) is jumpered to Pin 12 (Auxiliary DC Power Ground) and Pin 3 (Remote Interlock) is jumpered to Pin 4 (+5 VDC Auxiliary Power).

Symptom:

- An over temperature fault is indicated:

INT LED	– Green	Interlock Open	– Open
TMP LED	– Red	Over Temperature	– Closed
RDY LED	– Off	Laser Ready	– Open
SHT LED	– Blue	Shutter Open	– Closed
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- Water-cooled lasers – Cooling water temperature is above 22 °C (72 °F) or there is inadequate water flow through the laser.

Check that your chiller is maintaining a water temperature between 18–22 °C (64 °F–72 °F) at a flow rate of 2.0 gallons per minute (GPM). If water temperature is OK, check the flow rate. The simplest way to do this, if a flow meter is not available, is to disconnect the cooling tubing from the chiller inlet (or the drain) and run the cooling water for one minute into a five-gallon bucket; you should have close to two gallons. If there is much less than two gallons, check the cooling path for kinked or pinched cooling tubes and check the chiller for a clogged or dirty filter.

- Fan-cooled lasers – Cooling fans are not providing adequate airflow to either the laser or the RF power supply.

Check that all cooling fans are clear of debris and are providing an airflow rate of at least 130 cubic feet per minute per fan (t60) or 195 CFM per fan (t80/t100). To allow for proper airflow, cooling fans must have at least 2.25" (57.2 mm) of unobstructed clearance between the outside edge of the cooling fan housing and any mounting surface or enclosure.

- The *Interconnect* cable between the Laser Head and the RF power supply is damaged or disconnected, causing the temperature circuit to open. Note that an open or disconnected *Interconnect* cable causes *RDY*, *SHT*, and *LASE* indicators on the Laser Head to turn off.

Verify that the *Interconnect* cable is undamaged and that DB-9 connections on both the Laser Head and RF power supply are tight. Because over temperature faults are latched, you must cycle DC power to reset the laser.

maintenance/ troubleshooting

Troubleshooting

Symptom:

- A shutter closed condition is indicated:

INT LED	– Green	Interlock Open	– Open
TMP LED	– Green	Over Temperature	– Open
RDY LED	– Yellow	Laser Ready	– Closed
SHT LED	– Off	Shutter Open	– Open
LASE LED	– Off	Laser Active	– Open

Possible Causes:

- The *Shutter Switch* (if equipped) is Closed.

If your Firestar laser is equipped with a *Shutter Switch*, slide the switch to the Open position. The *SHT* indicator will illuminate blue.

- No voltage applied to Pin 10 (Shutter Open Request) on the *User I/O* connector.

Check to see that a positive or negative voltage (±5–24 VDC) is applied to Pin 10, Shutter Open Request, with respect to Pin 11, Input Common, on the *User I/O* connector (refer to *User I/O connections* in the Technical Reference chapter for details). If your system does not provide a Shutter Open Request signal, connect the factory-supplied *Quick Start Plug* to the *User I/O* connector on the RF supply's rear panel or wire your male DB-15 connector so that Pin 11 (Input Common) is jumpered to Pin 12 (Auxiliary DC Power Ground) and Pin 10 (Shutter Open Request) is jumpered to Pin 4 (+5 VDC Auxiliary Power).

Symptom:

- Your OEM laser has quit lasing or lasing halted and then restarted. The *LASE* LED may be Off or On depending on whether PWM Command signals are being applied, but no fault is indicated:

INT LED	– Green	Interlock Open	– Open
TMP LED	– Green	Over Temperature	– Open
RDY LED	– Yellow	Laser Ready	– Closed
SHT LED	– Blue	Shutter Open	– Closed
LASE LED	– Off or On	Laser Active	– Open or Closed

Possible Causes:

- An over temperature condition has occurred.

On B version OEM lasers only, over temperature faults are not latched. This means that if an over temperature condition occurs the *TMP* indicator will turn red, the Over Temperature output will Close, the *RDY* light goes out, and lasing is disabled. However if the laser cools down enough to clear the over temperature fault, the *TMP* indicator will change from red to green, the *RDY* light illuminates, and five seconds later lasing is enabled.

- The remote interlock circuit momentarily opened.

Remote interlock faults are not latched on OEM lasers. This means that if an interlock open fault occurs, the *INT* indicator will turn red, the Interlock Open output will Close, the *RDY* light goes out, and lasing is disabled. However, if the interlock circuit closes again, the *INT* indicator will change from red to green, the Interlock Open output will Open, the *RDY* light illuminates, and five seconds later lasing is enabled.

maintenance/ troubleshooting

Troubleshooting

Symptom:

- There is no output laser beam; all LED status indicators are Off.

Possible Causes:

- No DC voltage is applied.

Ensure that DC power cable connections are tight and verify that 30 VDC (t60/t100) or 36 VDC (t80) is applied to the RF power supply under full load.

Laser replacement

Symptom:

- When connecting a newer t60 Laser Head to an older RF-600 RF power supply (or vice versa) for troubleshooting purposes, the *Interconnect* cable will not attach.

Possible Causes:

- On newer t60 Laser Heads, the *RF Supply* connector is a male DB-9 connector; older t60 models used a female *RF Supply* DB-9 connector.

Caution possible equipment damage	Do not connect or disconnect the *Interconnect* cable while DC power is applied to the RF power supply. This may damage the RF supply's internal circuitry. Always remove DC power before connecting or disconnecting cables from the laser or RF power supply.

Although we recommend keeping t-Series Laser Heads and RF power supplies together as matched sets, in some cases it is useful to swap components for troubleshooting purposes. In situations where the *Interconnect* cable does not match the *RF Supply* connector on the Laser Head, it is permissible to attach a male/female gender-changing connector between the *Interconnect* cable and the Laser Head.

Beam delivery optics

Caution possible equipment damage	If you operate your laser or marking head in a dirty or dusty environment, contact SYNRAD about the risks of doing so and precautions you can take to increase the longevity of your laser, marking head, and associated optical components.

maintenance/ troubleshooting

Troubleshooting

Symptom:

- The laser loses power over time; laser output power must be increased to maintain performance.

Possible Causes:

- Beam delivery optics are coated by vapor residue or debris.

⚠ Danger serious personal injury	Ensure that DC power to the laser is turned off and locked out before inspecting optical components in the beam path. ***Invisible*** CO_2 laser radiation is emitted through the aperture. Corneal damage or blindness may result from exposure to laser radiation.

Shut down the laser and carefully inspect each optic in the beam delivery path, including the laser's output coupler. Remember that optics are fragile and must be handled carefully; preferably by the mounting ring only. If the optic requires cleaning, then refer back to *Maintenance* for cleaning instructions. Use only recommended cleaning materials (see Table 4-1) to prevent scratching delicate optical surfaces.

If the focusing optic is pitted, it must be replaced immediately. Because of the extremely high power density of Firestar lasers, pits or debris on the lens surface may absorb enough energy from the focused beam to crack the lens. If this happens, other optics in the beam path may be contaminated or damaged as well.

⚠ Warning serious personal injury	A risk of exposure to toxic elements, like zinc selenide, may result when certain optical or beam delivery components are damaged. In the event of damage to laser, marking head, or beam delivery optics, contact SYNRAD, Inc. or the optics manufacturer for handling instructions.

When the application requires air (instead of nitrogen) as an assist gas, we recommend the use of breathing quality air available in cylinders from a welding supply company. Because compressed shop air contains minute particles of oil and other contaminants that will damage optical surfaces, it must be carefully filtered and dried before use as a purge or assist gas. Refer to Table 3-1, *Gas purity specifications*, in the Technical Reference chapter for filtering/drying specifications.

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